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Distal Focussing of Perception: Size-Constancy in a Representative Sample of Situations

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Chapter I

Introduction

SITUATIONAL VS. POPULATIONAL GENERALITY

In a preceding article (5) the use of correlation coefficients was substituted for the "constancy ratio" (earlier developed by the present writer 3, 4, 46) as a method for measuring size constancy. The type of perceptual achievement called "size constancy" may be said to constitute an evidence of the good focussing of the perceptual system on the independent objective character of physical objects as contrasted with its poor focussing on the projections, per se, of these objects upon the retina of a subject. Correspondingly, in this preceding study, subjective estimates of size yielded high correlations with the "distal" stimulus variable to be perceived[1])—namely, "measured bodily size of objects"—and low correlations with the "proximal" stimulus variable—namely "visual angle", i.e. "projective", "photographic" or "retinal" size (cf. Chapter V).

This preceding study was carried out in a laboratory setup in which an array of arbitrarily selected sizes and distances was presented to eight subjects. The estimates given by the different subjects were averaged together, as if they had been those from a single subject. The "individuals" for computing the correlations were thus not the subjects but the different situations. And the "tests", or paired variables, which were correlated were the various types of physical size measurement—distal and proximal size—representing the stimuli or causes, on the one hand, and the size estimates (given by the one average subject) as the responses, on the other. On account of the arbitrariness and comparatively well controlled, singular character of the setup, this previous study is to be classed, however, as having been fundamentally of an "experimental" rather than of a "statistical" nature in spite of the fact that correlation coefficients were employed to represent the closeness of a stimulus-response relationship.

One of the most crucial difficulties of the experimental approach arises in connection with the question of the generality of the results. The use of the outcome of a certain more or less arbitrary experiment in predicting results in related but not identical situations is one of the "backdoors" through which premature generalization is likely to slip in unnoticed. Systematic variation of conditions, introduced in order to check up on the generality of an obtained stimulus-response pattern has been the ordinary remedy for this difficulty. Being "systematic," such a variation is in practice limited to the modification of conditions along a single or a few dimensions of the given setup, such as that of size,

[1] The term "distal", borrowed from Heider and the Gestalt psychologists (cf. 5, 31), designates the more or less distant environmental features defined without reference to the boundary of an organism. It is thus employed whenever the relative independence of an organism's response from variations in the mediating "proximal" variables, such as the size of the retinal images, is to be emphasized.

of distance, or of tonal frequency.[2]

The conception inherent in functionalism that psychology is the science dealing with the adjustment of organisms to the environment in which they actually live suggest the need of testing any obtained stimulus-response relationship in such a way that the habitat of the individual, group, or species is represented with all of its variables, and that the specific values of these variables are kept in accordance with the frequencies in which they actually happen to be distributed. As, say, in a survey of public opinion individuals must be selected so that the sample is representative of the reactions of the population as a whole, so in a study of perceptual achievement situations or tasks should be selected in such a way that the resulting sample is representative of the actual demands of the whole environment made upon the organism with respect to the actual stimulus variable under consideration (e.g. the variable of size of physical objects).[3] In comparison with the traditional domain of statistical methods, the field of inter- and intra-individual differences, relatively little systematic attention has been paid to this problem of the "situational generality" of experimental results, i.e., of generality with respect to the conditions of the stimulus- and response-situation, as contrasted with what may be called the "populational generality" of the individual differences studies. (Depending on the emphasis desired, such terms as "environmental generality", "circumstantial (or conditional, mediational) generality", and the like may represent more accurately what has been, somewhat hesitatingly, designated above as "situational generality".)

To be sure, specific control over the various mediating or circumstantial variables in the situation will, under the conditions just postulated, have to be given up in favor of generalized control within certain rather wide class limits. This means the abandonment of one of the fundamental policies of the experimental procedure in favor of a type of control characteristic, rather, of the typical statistical approach. In the conceptual isolation of a distal variable a natural flexibility of proximal mediation is indeed one of the most important requirements.

The present paper is an extension of the previous one (5) in that, in the study of size constancy, the correlation technique has again been used—along with measures of errors—, but in addition an attempt toward proper sampling of stimulus-response situations has also been made.[4] The application of fundamental policies of statistics has thus been rounded out. A relationship between organism and environment traditionally studied in the laboratory has been treated by a statistical survey in order to obtain greater closeness to life. Correspondingly, and in fact on account of the mere probability relationship between proximal stimuli, or cues, and the vitally more relevant distal objects, and of the resulting ambiguities in the evaluation of the proximal stimulus pat-

[2] See the recent interesting discussions of such variations by Spence (40) and Hull (26).

[3] A more complete recognition of the principle of randomization of tasks would imply that not even the selection of the stimulus variable itself should be left to the arbitrariness of the experimenter. Instead of being limited to one or a few physical dimensions, a perfectly balanced study of perception (or of any other function) would cover representatives of a large number of simple or complex stimulus variables in proportion to the demands for mastery of these variables in the life of the individual or type or species in question.

[4] An abstract of a preliminary report on some aspects of this study is given in (6).

terns on the part of the perceptual system of the organism, only imperfect correlations can be expected to hold between environmental variables and responses (cf. 7, 44).

The primary purpose of this study has been to give a methodological demonstration of the evaluation of responses to a random sample of test-situations. The specific problem of the perception of size has been used merely as an example. And, in accordance with this same primary purpose, the present study has in its main line been based upon the reactions of one subject only.

The subject, a graduate student in psychology, was interrupted at irregular intervals during the course of her daily activities, in various outdoor as well as indoor situations, and asked to indicate which linear extension happened to be most conspicuous to her at the moment. Though the sample of situations thus obtained may not be perfectly representative of "life", there is no doubt that it is more representative and variegated with regard to size, distance, proportion, color, surrounding pattern of objects, and other characteristics than any laboratory design could hope to be.

In each of these "life" situations, the subject had to give intuitive perceptual estimates of: (1) object size, (2) projective size (visual angle) and (3) distance. Since these estimates were supposed to be representative of uncritical perception only, the subject was then asked to repeat, in each situation, the first two estimates, but with critical judgment superimposed ("betting attitudes"). There was thus, a total of five estimates.

In order to obtain a second set of data for purposes of comparison (since this could be secured with little extra effort) the experimenter, who accompanied the subject, was also asked to go through the same series of estimates, independently of the subject, previous to his making the required geographic measurements of the stimulus variables in question.[5]

There were no restrictions on the free use of the cues and sensory facilities which ordinarily mediate the intuitive impressions of size. An analysis, proceeding after the pattern of this study, of the role of particular mediating sensory instruments or groups of instruments in the establishment of the perceptual constancies would have to be carried out by an artificial modification or elimination of specific sensory capacities and an observation of the resultant effects in investigations otherwise comparable to the present one. In an experimental setup and with the use of the constancy ratio, such an artificially controlled study of size constancy has already been undertaken by Holaday (25).

[5] Both subject and experimenter have normal vision.

Chapter II

Procedure

The present survey comprised a total of 180 situations; for 174, the data are complete. There were 19 experimental periods extending over four weeks, and separated from one another by intervals of from one hour to twelve days. In each period, from 5 to 23 situations were estimated. The time intervals between the situations were controlled by the experimenter in such a way that they varied randomly in length extending over not less than five and not more than sixteen minutes between successive sets of observations by the subject. The time required for each judgment was not specifically recorded but has been estimated not to have exceeded a few seconds in each case, with the more natural attitudes taking, on the whole, the least time.

The surroundings in which the survey was made included scenes on the street and campus, in the laboratory, at the desk, at home, and in the kitchen. An attempt was made to cover recreation and study, daytime and evening (including periods of artificial lighting) under conditions and in proportions representative of the daily routine.

The instructions given follow. The notations used throughout this paper for the various types of estimates are indicated in brackets.

"During the course of the experiment, please follow your daily routine as closely as possible. Each time a signal is given to you, notice the object, or group of objects, or empty space, which at the moment stands out as the prominent 'figure' in your visual field. Of that object, select the straight linear extension upon which you are most inclined to concentrate at the moment, no matter what the direction of this extension may be. (In case you have been looking at an empty space, this extension may well be a distance between two objects.)

"In the order given below, the following five attitudes should be taken in succession, and your judgment of size given in terms of the units of measurement most convenient to you.[6] Do not proceed to the next attitude before having registered your judgment on the prepared sheet. Do not move before having completed all five judgments.

"(1) *Naive perceptual attitude* [*b*]: Give your estimates on the basis of your first impression of the sizes of the objects in question. You should consider the sizes of the 'things' as seen in the ordinary attitude of daily life (not projective sizes relative to your location). Do not let yourself be influenced by your abstract knowledge about, or memory of, the sizes of the objects in question, or of optics, etc.[7]

"(2) *Analytical perceptual attitude* [*p*]: Try to perceptually analyze or to disintegrate the scene, in the way a painter would have to see it in order to be able to draw a perspectively correct picture—in other words, try to estimate visual angles, or the relative sizes of the projections of the objects as they could be measured on your retina or on a photograph with the camera set up where you are standing. Relate your judgment to an imaginary meter stick in a frontal plane at one meter distance from the eye.[8] As in

[6] Both subject and experimenter were brought up in the use of the metric system in daily life. This was an advantage for the purposes of the present survey.

[7] Regarding the question of whether or not the subject was actually able to let herself be guided by perceptual intuition rather than by knowledge, see Chapter IV B.

[8] That is to say, the judgment should refer to the extension, apparently cut out on an imaginary frontal plane at one meter distance, by the lightrays issuing from the object into the eye (but, of course, without the use of instruments such as a pencil held in front of the eye).

Illustrations and demonstrations of this kind

attitude (1), however, you should rely exclusively on perceptual appearance after the field has become reorganized in the fashion described.

"(3) *Realistic betting attitude* [b′]: As in (1), concentrate upon 'things'. This time, however, critically superimpose upon perception all abstract knowledge available to you. Take the attitude you would have, if you were to bet upon the sizes in question to the best of your knowledge.

"(4) *Analytical betting attitude* [p′]: As in (2), try to compare retinal (projective) sizes, again in relation to an imaginary meter stick at one meter distance. This time, however, take a betting attitude analogous to (3).

"(5) *Perception of distance* [d]: Perceptually judge your distance from the object, on the basis of your first impression, in analogy to attitude (1)."

The experimenter's main function (aside from serving as a control subject) was to control the time intervals between situations, to record the general type of the object or situation responded to by the subject, and to measure physical sizes and distances of the extensions designated by the subject, or to secure a basis for their trigonometric computation.

were presented until it was assured that both subject and experimenter thoroughly understood the meaning of the instructions.

Physical projective size was easily ascertained by dividing physical bodily size by physical distance (in meters). Bodily size was similarly ascertained if distance and projective size only could be physically determined. In like manner calculations were made for distance. In some cases the objective data had to be ascertained by consulting a map, or by inquiry, such as in the case of some of the larger distances or of signs erected on the top of a building, and the like. In eight cases of body size and in one case of a distance (out of our total of 174 complete situations) the exact measurements could not be obtained, and carefully scrutinized estimates had to be substituted.

Chapter III

Distribution and "Ecological" Interrelations of Geographic Variables

Figure 1 shows, for the situations selected by the subject, the environmental, 'geographic' data only, namely the distribution of the physical object sizes (bodily extensions, B), physical projective sizes (P) and physical distances (D) as measured, computed or otherwise objectively ascertained by the experimenter. For reasons of convenience, of the Weber law, etc. (see below), all data are plotted logarithmically,[9] with the use of .5 as the class interval. The limits of the intervals are at 1 mm. (corresponding to a logarithm of zero), 3.16 mm. (corresponding to a logarithm of .5), 10 mm., 31.6 mm., 100 mm., etc. For more precise references see Figure 2.

The logarithms of the 174 bodily extensions for which the data are complete are fairly normally distributed, as shown by the dotted line in the left graph of Figure 1. The extensions which have been omitted from the original 180 for reasons of incompleteness of the data are large (such as, e.g., the height of a flying airplane which could not be ob-

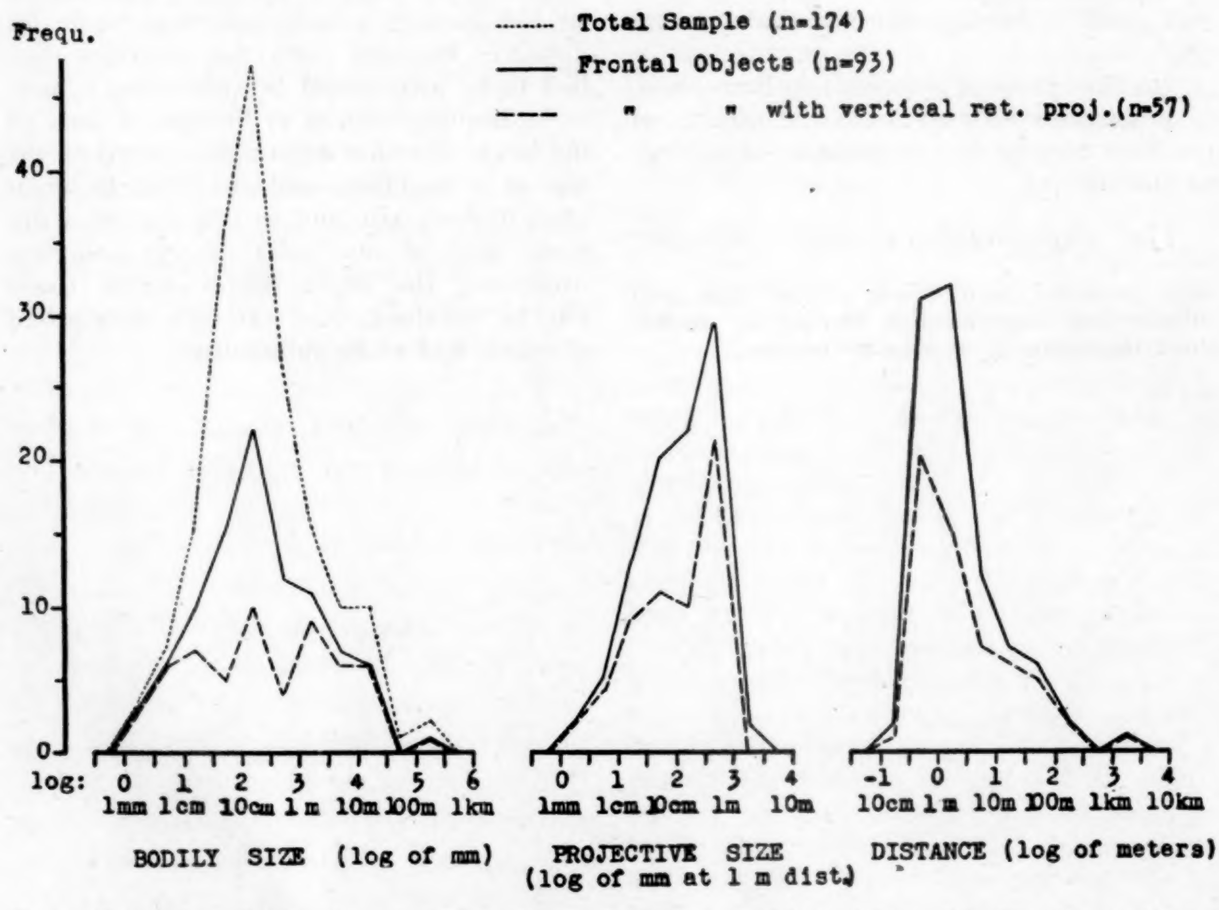

Fig. 1. Frequency distribution of the logarithms of the geographic variables of bodily size, projective size and distance, characterizing the sample of extensions spontaneously responded to by our subject.

[9] All of our quantitative results are in terms of this particular type of measure.

jectively ascertained) and thus, if presented, would have added to the upper end of the distribution.

The further considerations in this paper are not, however, based on the entire material, but on a sample of 93 situations which remain after all the extensions tilted into the third dimension, and thus distorted (fore-shortened) on the retina, have been eliminated. In this remaining standard group of 93 situations, data are complete for all items. By definition, this final sample comprises the frontal objects, i.e. the extensions which are oriented perpendicularly, or approximately perpendicularly, to the line of regard of the subject. The present study thus is limited to problems of size constancy proper (involving variations in the distance of objects) and excludes problems traditionally classified under "form-constancy", or estimates from situations involving rotation into the third dimension. (An analysis of the size-constancy of tilted objects, based on the total sample of 174 situations, might be presented in a further publication.)

The phrase 'perpendicular to the line of regard' which defines the extensions included in the frontal group, refers primarily to cases in which the perpendicular from the eye strikes the object somewhere near the middle and in which the visual angle is not too large so that the ends of the object are not too much distorted on the retina. Of the 57 upright frontal objects, for example, 44 fulfill the former requirement in a relatively strict sense (24 of the latter being approximately vertical and 20 being seen by looking downward, as in reading a book). In the remaining 13 cases it is one of the ends of the objects which is seen perpendicularly, the position of the entire object thus being only approximately frontal. As can be inferred from Figure 2, the largest visual angles in our frontal group are about 45°, which corresponds to a projective size of one meter at one meter distance, or a tangent of 1. Situations such as the height of a house seen from a very short distance have been excluded from the frontal group though the lower portion of the house was in frontal position.

Regardless of the exact details of position, for all extensions classified as frontal, projective size (P) was computed by simply dividing bodily size (B) by perpendicular distance (D), i.e. by subtracting their logarithms, thus using the tangent of the visual angle in each case. Due to this standardization of procedure, errors up to a little more than 15% are possible in the physical determination of the projective size of the objects which were only approximately frontal.

In inferring retinal proportions from projective size as computed above, a further source of error is introduced by the absence of a perfectly frontal orientation of the marginal portions of the 'frontal' objects (or of their projections on a frontal plane) which are seen under a comparatively large angle. In our frontal group, however, this increase (which is defined as the difference between the length of the arc and the tangent of the visual angle) can never exceed somewhat more than 20% (.08 logarithmic units).

Even when combined, the maximum error possible as a result of the simplification of the procedure in finding retinal size is still small when compared with the variability of projective sizes since the largest of our retinal extensions is 1,000 times as large as the smallest. In terms of the logarithmic scale, the error could in no case exceed .15, or 1/20 of the total logarithmic scatter of projective sizes which covers the range from about 0 to about 3. (The figure .15 corresponds to an antilogarithm of 1.4 which is the factor accounting for an increase of 40%.) This potential maximum also is less than half of the average of the absolute logarithmic errors committed by the subject in perceptually estimating projective sizes, namely .34 (see below, Table 1).

As shown by the solid line in the left graph of Figure 1, the 93 frontal extensions also are distributed approximately normally, when plotted logarithmically. This fact may be taken as an indication (though not a definite assurance) that

our sample is representative. It may also be taken as a further justification for our policy of using logarithms in representing magnitudes. Bodily sizes range from a few mm. to more than 100 meters. Most frequent are sizes between 10 and about 30 cm., corresponding to the interval of logarithms of mm. between 2 and 2.5. The broken line refers to the 57 'uprights' of the 93 frontal objects. These 'upright' objects were projected approximately onto a vertical section through the optic center of the eye (i.e., along the intersection of the retina and the median plane). This would be the case for many vertical objects, letters seen when reading a book, and the like.

The middle diagram shows the distribution of projective sizes computed by dividing bodily size (in mm.) by perpendicular distance (in meters). Thus projective size is here defined as the extension, in mm., which is actually cut out by the light rays approaching the subjects, on a plane parallel to the subject's fovea at one meter distance from the eye (an arbitrary reference distance). Sizes on the retina itself are roughly proportional to these projective sizes so that the two concepts may in first ap-

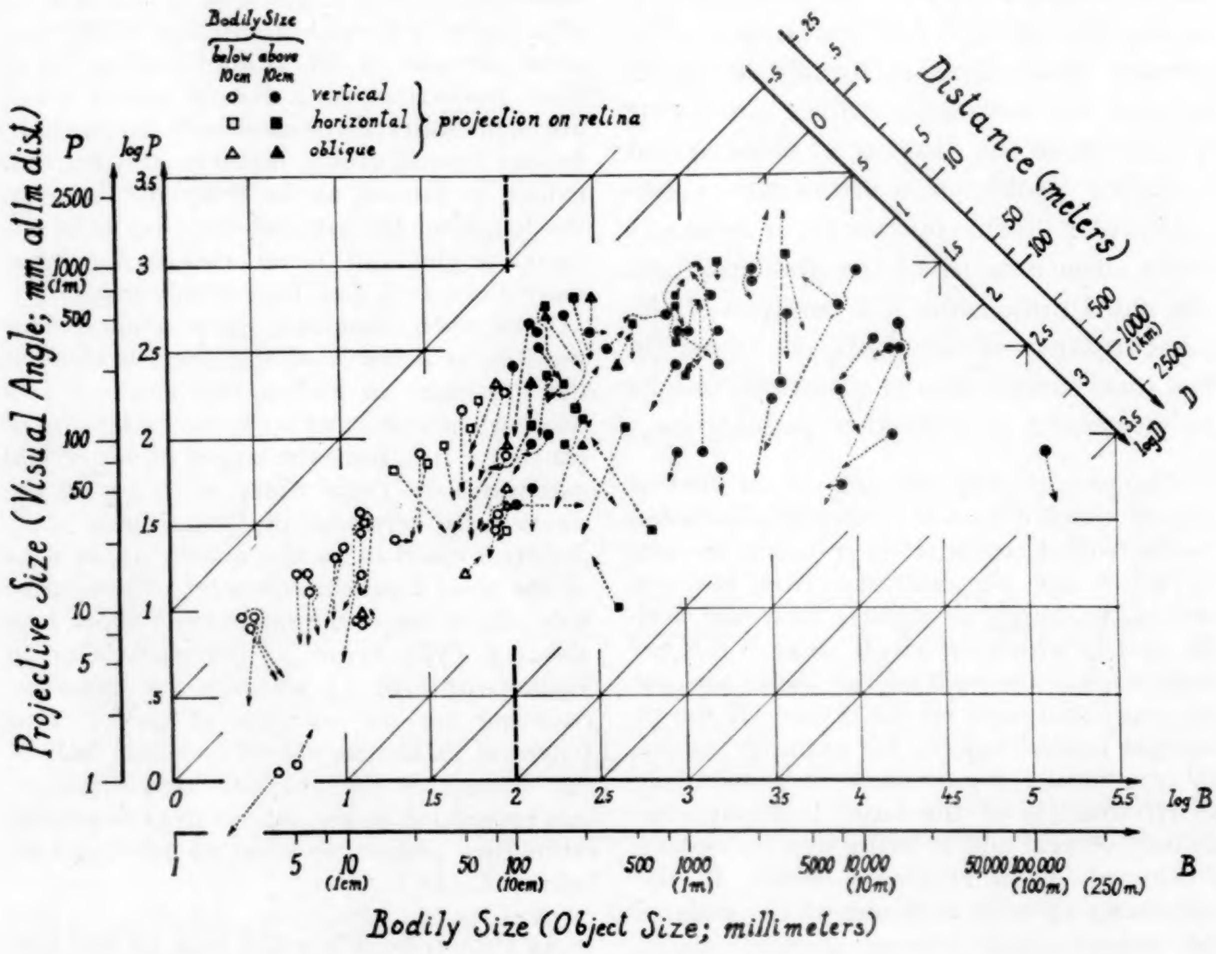

FIG. 2. The 93 frontal extensions plotted in a field defined by the three functionally interdependent geographic variables of bodily size, projective size and distance. The symbols (solid and outline squares, circles and triangles) are placed at the intersection of the three mathematically interrelated measurements (B, P and D) characterizing each object or situation geographically. The arrow-head connected with each symbol is based upon the respective pair of estimates of bodily size and projective size (b and p) used as coordinates. (This point does not necessarily coincide with the explicitly estimated distance, d, which is not represented in this scheme; see Chapter VI.)

proximation be used interchangeably, as was done above. The solid line refers to the 93 frontal objects. The distribution is skewed to the left, showing that the most frequent projective sizes are about 30 cm. to 1 meter. These also tend to be the maximal projective sizes. This modal interval corresponds to visual angles averaging around 35°. Some of the visual angles are, however, as small as 4 to 10 minutes of arc; and there is a gradual transition between the two extremes. The broken line again represents the 57 upright projective sizes. No computations were made for the relative sizes of the retinal representations of the extensions tilted into the third dimension.

Distances range all the way from 10 inches up to about a mile. They are shown in the righthand graph of Figure 1 in which logarithms of meters are used as abscissae. The most frequent distances are between about 30 cm., the ordinary reading distance, and some 3 meters. The distributions are positively skewed both for the entire group of frontal objects and for the group of 'upright' objects only. Again, no curve has been drawn for the total group. Many of the tilted extensions were in themselves so large and extended so far into the third dimension that it would have been difficult to assign to them any precise distances from the subject.

In Figure 2, the small circles, squares and triangles may be discussed first, disregarding for the moment the arrows connected with them. These symbols still deal with the purely physical aspects of the sample selected by the subject and show the relationships between geographic bodily object size, B (horizontal axis of diagram); geographic projective size P (vertical axis of diagram); and geographic distance, D (shown at upper right of figure, and pointing downward). The three geographic variables can be represented in a two-dimensional field since they are, in a functional, mathematical sense, strictly interdependent, as defined by the equation $P = B/D$, or $\log P = \log B - \log D$. (P in its turn is equal to the tangent of the visual angle under which the object is seen, provided that both B and D are expressed in terms of the same unit.) Logarithms were again used throughout in plotting each of the 93 frontal situations. Of the total of 93 symbols the circles represent the 57 approximately upright frontal extensions, the squares, the 25 approximately horizontal frontal extensions, and the triangles, the remaining 11 oblique frontal extensions. Outline symbols refer to extensions smaller than 10 cm., solid ones to those of 10 cm. or over (see below).

The smallest extensions were mostly heights of printed or typed letters; the largest were heights of buildings, church towers, flag masts, trees, or hills. The uppermost square represents the length of a wall, the lowest, the width of a chimney. Examples of other frontal extensions are: length or width of matches, ashtrays, cups, bottles and other utensils, household goods, instruments, chess figures, books, furniture, windows, street signs, pavement squares, posters, etc. Empty distances such as the height of a room, or the distance between shelves, etc., were almost absent among the frontal objects, but comparatively frequent among the tilted ones which are not included in this presentation.

Most conspicuous general feature in Figure 2 is the fact that geographic bodily size, B, and geographic projective size or visual angle, P, are statistically correlated. The Pearson coefficient, from the data grouped in logarithmic intervals of .5 as indicated by the pattern of cells,

and corrected for grouping, is $r_{BP} = .70$ for the entire frontal sample of 93. This correlation may be called an "ecological" one since it deals with a purely internal relationship between geographic variables relevant to an organism within the habitat of that organism (including the boundary between the organism and its surroundings), rather than with a relationship between a habitat variable and a response variable as is the case for the relationships discussed in subsequent chapters of this monograph.[10] The intrinsic imperfection of ecological relationships (7) finds its expression in the fact that r_{BP} is not 1.

This relationship is, however, due primarily to the fact that sizes smaller than 10 cm. are in daily life ordinarily all looked at from the same most favorable distance of about 30 cm. (see Fig. 2). This leads to a close tie between bodily size and retinal size within this size range.[11] The relationship also assumes a slightly curvilinear trend. The correlation disappears almost completely when only sizes above 10 cm. are considered. They are cut off in Figure 2 by the broken vertical line, and also represented by solid as contrasted to outline symbols. The correlation between B and P for this group of 59 objects is only .14. If the selection of objects to attend to in three-dimensional space, made by our subject is representative, there is, then, in an unbiased distribution of those objects which are all larger than 10 cm., a not much greater likelihood for large objects to cast large retinal images than for small objects to cast large retinal images, and vice versa. In other words, increase in the size of objects above 10 cm. is usually compensated for by an increase in distance. The visual angles thus remain of about the same orders of magnitude for stimuli coming from objects of all different sizes and at all the various distances.

This independent variability—in a statistical sense—of B and P for sizes above 10 cm. (which is quite compatible with the functional or causal relationship existing between these two and distance) will be a valuable feature in our subsequent efforts to isolate for study the focalization of the subject's response on the distal stimulus, B, from focalization of her response on the proximal stimulus, P.

As can be seen from a further inspection of Figure 2, there also is a marked positive relationship between B and D; the coefficients are .77 for the total frontal sample and .88 for the objects larger than 10 cm. This is a direct expression of the propensity of the subject to concentrate upon larger objects when looking at larger distances, or vice versa.

Projective size, on the other hand, shows almost perfect independent variability—in a statistical, ecological sense again—from distance (.08), with the relationship becoming slightly negative (−.34) for objects larger than 10 cm.[12]

[10] Some authors, for example Lewin, would probably prefer to use the term "ecological" to characterize relationship between organism and geographic environment. Since the Greek word *oikos* means home or homeland, and since no term is available to designate an analysis of intra-environmental physical relationships relevant, in an objective sense, to an organism living in its home region, the present writer suggests the use of the term as indicated above.

[11] r_{BP} for the 34 objects smaller than 10 cm. is .73. Considering the decrease in variability of B (and also of P) effected by the limitation to small sizes, this coefficient means more than a direct comparison with the one obtained for the entire frontal group would suggest.

[12] By partialling out D, P and B, respectively, from the six coefficients mentioned in the text, partial correlations of 1 are obtained between

There is thus, if our sample of situations is representative, only a slight chance of successfully predicting distance from the visual angle of the objects of attention in the natural habitat of a present day intellectual, since a certain retinal size is about as often due to a comparatively small object at a small distance as to a comparatively large object at a large distance.

B and P and between B and D, and of −1 between P and D. This fact is due to the perfect dependent variability—in a functional sense—of the three physical variables discussed.

Chapter IV

Correctness of Perceptual Responses in Terms of Error

The dotted arrows extending from each symbol in Figure 2 are based on the first two types of estimates (verbal responses) given by the subject in each situation, b and p. As has been explained above, b refers to the "immediate", or intuitive, perceptual impression of bodily magnitude elicited by the object, p to the intuitive impression of projective values or photographic size obtained as a result of shifting toward the analytic attitude.[13] Each arrowhead is located at the point of our diagram combining the two estimates for the object in question, and using the same axes as for B and P, respectively. Each arrowhead thus represents, for the physical stimulus situation (an object of size B at the distance D possessing the projective value P) to which it is attached, the corresponding set of perceptual responses or "appearances", b and p (but, on account of perceptual inconsistencies, not necessarily of d, see Chapter VI). Length and direction of the arrows, or rather of their horizontal and vertical components, indicate magnitude and direction of errors of judgment in logarithmic terms.

(A) Perceptual size-constancy vs. "constancy hypothesis"

It becomes quite clear from a mere visual inspection of Figure 2 that arrows on the whole extend vertically more than horizontally, indicating greater errors for projective size than for bodily size. This is one of the several ways of expressing the establishment of "size constancy" and the comparative neglect of the retinal size relationships, per se, by the perceptual system. If the "constancy hypothesis" inherent in traditional structuralism (presupposing a strict one-to-one relationship between

Table I

Focussing of perception upon distal rather than proximal stimuli (size constancy). This is here illustrated by logarithmic constant errors and their sigmas as well as average absolute errors, with respect to bodily size and projective size, for subject and experimenter, in uncritical perceptual attitudes and in "betting" attitudes, for all 93 frontal extensions.

Attitudes	Subject				Experimenter			
	Means of algebraic deviations ("Constant Error")		Means of absolute errors (Variability)		Means of algebraic deviations ("Constant Error")		Means of absolute errors (Variability)	
	for B	for P	for B	for P	for B	for P	for B	for P
	$CE \pm Sigma_{CE}$	$CE \pm Sigma_{CE}$			$CE \pm Sigma_{CE}$	$CE \pm Sigma_{CE}$		
Uncritical perceptual (b and p, respectively)	$-.035 \pm .015$	$-.208 \pm .038$	.117	.339	$+.020 \pm .011$	$-.131 \pm .040$	.079	.325
"Betting" (b′ and p′, resp.)	$-.011 \pm .010$	$-.234 \pm .041$	.080	.366	$-.003 \pm .010$	$-.188 \pm .039$	.078	.344

[13] A tendency to give round numbers is revealed by the fact that estimates are often given in terms of one-place numbers and rarely ever, except for distance judgments, involve more than two significant digits (not counting zero unless followed by a digit other than zero). This tendency is likely to increase errors; no further analysis of such effects is, however, undertaken in this study. Effects of practice have likewise not been especially analyzed. Considering the problems emphasized in this study they have, if present, probably not affected the general pattern of the results a great deal.

proximal stimulus element and "sensation", cf. 31) were true, errors with respect to projective size should be small.

Computation of the average lengths of the two orthogonal components of the arrows has confirmed these findings quantitatively. Various kinds of averages of errors made in the purely perceptual attitudes with respect to B and P are presented in the first row of Table 1, the errors being defined as log b — log B, and log p — log P, respectively. The averages thus actually represent the logarithms of the geometric means of the ratios between the raw estimates and the corresponding raw measurements, b/B and p/P, respectively.

The averages with the signs of the errors taken into consideration may, for the sake of brevity, be labelled "constant errors" (CE) though this term has thus far been applied primarily to cases in which at least part of the disturbing features causing the error has been systematically stabilized or specifically controlled for the entire experimental series. Sigmas (standard errors) of the constant errors are also given.

For our subject, the algebraic error for bodily size B is on the average −.035 in terms of our logarithmic scale. This value corresponds to an underestimation of B of about 7%. The constant error for projective size P, −.208, is about six times as large, corresponding to an underestimation of P by about 38%. For the experimenter in his role as a control subject the constant error with respect to P is seven times that for B, but the sign of the latter is positive and its amount, corresponding to an overestimation by only about 5%, is slightly under twice its own standard error. The significance of the difference between constant errors for B and for P, to be derived from the attached sigmas, is characterized by a critical ratio of 4.2 for the subject, and of 3.7 for the experimenter when the sign of the constant error is taken into consideration and of 2.7 when only the absolute magnitudes of the constant errors are compared.

Fractionated constant errors and their sigmas shown in Table 2 indicate a high level of significance for the difference between constant errors for B and P as far as objects within reach of the hand are concerned, with a critical ratio of 9 for the subject and of 14 for the experimenter for frontal extensions at distances less than one meter.

Measures of variability about the correct physical values may generally be more adequate than are constant errors in dealing with problems such as ours. To the right of the constant errors and their sigmas in Table 1, averages of errors, with the signs of the errors disregarded, are shown for B as well as for P. They are defined as averages of the 93 |log b − log B|, and of the 93 |log p − log P|, respectively.

These means of absolute errors (crude average errors) are measures of the variability of the estimates about the actual geographic values, or about an error of zero. Again, the values for P are considerably larger than those for B, in fact, about three times as large in the case of the subject and about four times in the case of the experimenter; the largeness of the difference is, however, in part due to the large constant error found for P.

Fractionated sigmas in Table 2 point in the same direction, the values for P being about two to five times as large as the corresponding values for B in the various distance categories.

As can be seen from Figure 2, the longest single horizontal component of an arrow extends over a little more than one cell,

representing the height of a column of 10½ meters at a distance of 11 meters which had been estimated by the subject to be 2.9 meters high. In the same situation, the subject has also committed her largest error regarding projective size, represented by a vertical arrow-component about twice as long as the horizontal one, extending over more than two cells, i.e. one entire logarithmic unit; more precisely, projective size has in this exceptional case been estimated to be only about 1/12 of its actual value.

(B) UNCRITICAL PERCEPTUAL ATTITUDES VS. RATIONALLY CONTROLLED JUDGMENTS

In the second row of Table 1 are shown, for subject and experimenter, results with the two types of "betting attitudes," b′ and p′, in analogy to the upper row which refers to the two intuitive perceptual attitudes. Reactions to B are in general more precise (i.e. errors are closer to zero) in the betting attitude than in the uncritical attitude. The significance of this improvement is, however, not established when the figures are compared item by item. For the experimenter, the constant error reaches the low of −.003 with a sigma of .010.

For P the opposite is true, and the tendency toward an increase of constant error and variability is consistent for all the four comparisons that can be made.[14]

One of the principal difficulties in an investigation like the present is the question of whether the estimates given are based on genuinely perceptual, intuitive responses or whether they are merely reflections of more or less explicitly intellectual processes, including memory for numbers, etc. If this question is phrased in the usual introspective manner no decisive answer can be given to it, since no introspective alternative can be settled in an exact way as long as it has not been redefined in terms of objective criteria.[15] The above comparison of the so-called naive perceptual attitude with the betting attitude may nevertheless be taken as an occasion for the following rather casual remarks regarding the perceptual nature of the responses upon which this study is based.

According to the reports of both subject and experimenter none of the extensions estimated happened to be explicitly known to them in quantitative terms as a result of previous measurement or communication; consequently, the impression gained in the momentary situation had to be employed in each case. Familiarity with the objects, based on manipulation, as well as practical familiarity with the size of nearby objects, was of course given in many instances. This, however, is true in most cases of everyday perception, and the elimination of the factor of manipulatory familiarity would have seriously violated the principle of representa-

[14] In the study on size constancy by Holaday (25, p. 462), rational control was found on the average to result in greater correctness with respect to the "intended" variable, whether this variable be bodily size or projective size, without, however, fully compensating for the trends found in the purely intuitive approaches. Deviations of the constancy ratios from the ideal values 100 and 0, respectively, were being cut approximately in half.

A similar improvement was found in an as yet unpublished study by Marianne Müller (37) on the Müller-Lyer illusion dealing with the problem of the perceptual compromise between length and area. Six different attitudes were to be taken, some of them concentrating on length, others on area and on esthetic balance. The sixteen subjects showed on the average a 28% constant error with respect to length in the whole-perceiving attitude toward length. The corresponding betting attitude (the only betting attitude employed) yielded a constant error of only 16%, a figure which is also better than that obtained when an analytic perceptual attitude toward length was taken, 22%.

In the study of Mohrmann on loudness constancy (36, p. 184) the transition from the purely perceptual to the betting attitude resulted in confusion and deterioration of performance rather than in an improvement.

[15] In an attempt to overcome this difficulty, the present writer suggested a revision of the distinction between intuitive perception and rational approach to reality—and in fact, between various attitudes in general—in terms of a statistical analysis of the types and distributions of errors committed, that is, by an objective analysis of achievement rather than by direct introspection (4). No systematic use of such a procedure can, however, be attempted here. Indications of what might be called the relative autonomy of the perceptual system have been pointed out repeatedly by the present author.

tive sampling of situations which was set forth in the beginning of this paper.

A more objective criterion as to whether or not judgment is determined by memory for numbers may be obtained by comparing the frequency of instances in which judgment of size is perfectly correct with that of those in which it is not. In the former instances, provided that they are more frequent than chance, one may suspect abstract knowledge to have slipped in unnoticed. In Figure 2, these cases are represented by the perfectly vertical arrows, indicating that measurement of B and judgment b were in perfect numerical agreement. There are 9 such cases for the subject, out of a total of 93; the corresponding figure for the experimenter (not represented in the graph) is 11. This proportion is rather low in view of the fact that some of the measurements involved were taken to one significant digit only, and that exact correspondence did never occur in cases in which either measurement or naive perceptual estimate had been carried to more than two digits. Thus the tendency of the perceptual estimates toward round numbers (see footnote 13), in connection with the high degree of general correctness of judgments of bodily size, sufficiently accounts for the fact that the above-reported approximately ten percent perfectly correct responses were given. Unless one wishes to bring into the picture the possible significance, for our estimates, of abstract knowledge that is only approximately correct, there is thus no need to assume inroads of the higher cognitive functions upon perception as far as the naive realistic attitude is concerned.

A further corroboration of the relative autonomy of the system determining estimates of the type b, on the one hand, and of rational knowledge, on the other, may be gathered by comparing the perfectly correct responses given in attitude b with those given in the rationally infiltrated betting attitude b′. There is relatively little overlapping between the two. Of the 14 perfectly correct judgments given in attitude b′ by the subject (16 for the experimenter), only 3 (experimenter, 6) are among those 9 (experimenter, 11) for which responses were correct in attitude b.

The scarcity of explicit knowledge of bodily sizes is further indicated by the fact that in all of our material there is only one case in which judgment is correct for a measurement which was taken to 3 significant digits. The diagonal of a panel, measuring 108 cm., was estimated to be 108 cm. by the experimenter in the betting attitude, b′. This extension might have been incidentally measured by the experimenter at a previous occasion without his explicitly remembering it.

(C) COMPROMISE TENDENCY BETWEEN DISTAL AND PROXIMAL FOCUSSING

Comparing objects at small distances (upper left diagonal of Figure 2) with objects at larger distances (lower right-hand part of diagram), it will be noted that there is an increase in the frequency and degree of left-pointingness of the arrows, indicating a stronger tendency toward underestimation of bodily size for objects at greater distances. This tendency is graphically not quite as clear as the one discussed under (A), yet it is also found to be significant after computation. The upper part of Table 2 shows constant errors and their sigmas, the objects being divided into three distance categories with approximately equal numbers of cases in each category. For the subject, there is no constant error when the 34 object-sizes at distances less than one meter are taken together. There is, on the average, a slight underestimation of the 31 objects in the next higher distance category, and considerable underestimation for the 28 objects at about three meters or more. The latter amounts to a geometric mean of algebraic errors of more than 20% (corresponding to the antilogarithm of −.099 which is .796, or about 20% below 1). The difference of the two extreme groups is significant at the 1% level of confidence. The experimenter shows a similar tendency, though considerably less clearly. For him the slight overesti-

mation of objects decreases with increasing distance.

As should be expected, we find, corresponding to the underestimation of far object-sizes, that projective sizes are estimated higher (or underestimated to a lesser degree) when the objects causing the image are at a greater distance and thus possess a comparatively large bodily extension than when they are near at hand. Table 2 shows significant trends of this sort for both the subject and the experimenter.

The finding of the comparative overestimation of bodily sizes of near, and of projective sizes of far objects may be subjected to the argument that the cause of underestimation is to be sought in the largeness rather than in the sheer distance of far objects. The existence of a positive correlation between D and B has been mentioned above and is also directly evident from Figure 2. It is also shown by the increase of average B with the increase of distance in Table 2 (upper part of the column showing average log B). To meet this argument, the 93 standard frontal objects were re-grouped, for each class interval of B, into a less-distant and a more-distant portion (if possible, equal numbers in the two portions) so that in the end the two resulting groups of 46 comparatively near and of 47 comparatively far objects were as closely equated with regard to B as possible. The result of this rearrangement is shown in the middle part of Table 2. In spite of the fact that the logarithmic averages for distance are still different by .55 logarithmic units (the near group averaging around 1 meter and the far around 4 meters, corresponding to .04 and .59), average B shows only a difference of .01 for the two groups. The responses show a trend that is similar to that discussed for the upper part of the table, though, as was to be expected on account of the decrease in differences in distance, less clearly and well below the level of significance as far as errors with respect to B are concerned. There is even a small, insignificant reversal in the case of the experimenter.

In order to eliminate the relative closeness of the average distances for the two groups of objects distinguished in the middle part of Table 2, and yet to avoid differences in size as much as possible, a third way of grouping was introduced using objects in a middle size range only, but applying a clear-cut distance criterion as in the first type of grouping. The 52 objects between 10 cm. and 10 meters in size were divided into two approximately equal groups comprising distances above and distances under two meters.

TABLE 2

Tendency toward comparative underestimation of distant objects as represented by logarithmic constant errors and their sigmas for objects at different distances.

The upper part of the table shows the results when the 93 frontal extensions are grouped into three distinct distance categories not equated for B. In the middle part the 93 objects are regrouped in such a way that the geometric means for B are approximately the same in each of two distance groups. In the lower part a middle range of sizes is split into two distinct distance categories.

Distance		No. of objects	Ave. log D (m.)	Ave. log B (mm.)	Subject's Constant Errors		Experimenter's Constant Errors	
					for B	for P	for B	for P
					CE ± Sigma$_{CE}$	CE ± Sigma$_{CE}$	CE ± Sigma$_{CE}$	CE ± Sigma$_{CE}$
Grouping of 93 objects not equated for B	Less than 1 m. (log below 0)	34	−.36	1.54	+.000 ± .019	−.430 ± .042	+.023 ± .014	−.416 ± .029
	1 m. to 3.16 m. (log from 0 to .5)	31	.26	2.39	−.015 ± .026	−.121 ± .050	+.025 ± .016	−.062 ± .037
	3.16 m. and more (log = .5 and more)	28	1.21	3.31	−.099 ± .034	−.034 ± .088	+.009 ± .031	+.132 ± .081
Same, equated for B	Comparatively near	46	.04	2.37	−.022 ± .012	−.294 ± .063	+.018 ± .014	−.235 ± .052
	Comparatively far	47	.59	2.38	−.044 ± .020	−.122 ± .052	+.022 ± .015	−.024 ± .053
B from 10 cm. to 10 m. (52 objects)	Less than 2 m. (log below .30103)	24	−.11	2.42	−.008 ± .021	−.207 ± .045	+.022 ± .010	−.166 ± .043
	2 m. and more (log = .30103 and more)	28	.83	3.01	−.014 ± .030	+.022 ± .075	+.013 ± .022	+.074 ± .093

Results are shown in the lower, third part of Table 2. The difference in average distance between the two groups is now .94 (covering the interval from about 80 cm. to about 7 meters) instead of .55 as in the middle part of the table. Average bodily size is different for the two groups, though by no means as drastically as in the upper three rows of the table. The trend in the results in each case confirms the previous conclusions, though again below the level of significance.

Thus previous assertions regarding imperfection of the constancy mechanism in the direction of a slight overestimation of near and underestimation of far objects seem, on the whole, to be corroborated rather than contradicted. In other words, our results point toward a slight interference on the part of retinal size, per se, with the focussing of the perceptual system on the distal variable, bodily size (as mediated by retinal size in conjunction, of course, with a number of other proximal stimulus features, such as distance cues).[16] The generality of these experimental findings has sometimes been questioned but is now supported by our present sample of situations which is more representative of normal perception at large than were the situations involved in the previous laboratory experiments. Significance is reached, however, only when bodily sizes are permitted to be scattered over the various distances in an unconstrained fashion, distance as a variable then not being freed from its natural ties with bodily size. In view of the fact that this study is dealing with a statistical survey rather than an experiment we need not, however, be too much concerned with this lack of isolation of the two variables.

TABLE 3

Data pertinent to the problem of the "vertical illusion."

Logarithmic constant errors in estimating horizontal and vertical extensions support neither the distal nor the proximal interpretation of the vertical illusion.

Direction in visual field		Number objects	Ave. log D (m.)	Ave. log B (mm.)	Subject's Constant Errors		Experimenter's Constant Errors	
					for B	for P	for B	for P
					CE ± Sigma$_{CE}$	CE ± Sigma$_{CE}$	CE ± Sigma$_{CE}$	CE ± Sigma$_{CE}$
Horizontal		all 25	.15	2.36	−.021 ± .030	−.218 ± .089	+.041 ± .021	−.092 ± .084
Upright	{	all 57	.41	2.43	−.046 ± .020	−.203 ± .039	+.008 ± .013	−.126 ± .050
		corresp. 25	.17	2.35	−.054 ± .023	−.215 ± .072	+.014 ± .014	−.178 ± .058
Oblique		all 11	.06	2.16	+.007 ± .048	−.191 ± .069	+.026 ± .016	−.245 ± .078

(D) OVERESTIMATING THE VERTICAL?

Another previous statement of experimental psychology, although it does not belong to constancy research proper, may now be discussed briefly as a supplement. It is the so-called "vertical illusion". Unlike the findings of constancy research, this illusion, consisting in an overestimation of the upright as contrasted to the horizontal, seems, on the basis of our results, not to be generalizable beyond the limits of those experimental conditions under which it has thus far been studied.

In fact, when errors for the twenty-five horizontal objects (represented by squares in Figure 2) are algebraically averaged and compared with those for

[16] An alternative expression for this would be to say that a "compromise object" (*Zwischengegenstand*) between bodily size and angular size is to be considered as the "intentionally attained" type of physical object or variable (4).

the 57 upright objects (represented by circles), an opposite tendency—toward comparative underestimation of the upright—is found, though below the level of significance. As is shown in Table 3, average estimates b, measured in terms of correct sizes B, are higher for the horizontal than for the vertical (−.021 vs. −.046); the difference is, however, not quite as large as its standard error. An analogous trend is found in the experimenter's results: there is a decrease in his general tendency toward overestimation when we proceed from the horizontal to the upright extensions, but again the difference (.041 vs. .008) is not significant, the critical ratio being only 1.4.

Similar results are obtained when the 25 horizontal objects are compared with those 25 of the 57 upright objects which correspond most closely in distance and magnitude to the horizontal ones. As can be seen from the left part of Table 3 the two groups of 25 objects match very closely with regard to average D as well as with regard to average B. Again for both subject and experimenter estimates are comparatively lower for the upright than for the horizontal (in terms of algebraic deviations from the physical values), but again the difference hardly reaches its own sigma.

For comparison, the corresponding data on the 11 oblique extensions are also given in Table 3. On account of the small number of cases, however, no comment is made.

Since experiments of the traditional psychophysical type suffer from a lack of independence—in a statistical sense—and thus of isolation of distal and proximal variables, due to the stability of the mediating conditions (such as distance) under which the experiment is set up, it seems appropriate to check the vertical illusion not only in terms of B but also in terms of P. As shown in Table 3, the constant errors of the subject are nearly equal for all the comparisons to be made, whereas the experimenter shows, in conformity with the trends noted for B in both subject and experimenter, a slight and not significant tendency to under-rate the upright more than the horizontal.

The vertical illusion is thus counterindicated, or at least not positively confirmed, by our representative sample of extensions and situations, whether it be conceived as referring to distal or proximal size as the crucial stimulus-variable.

(E) "SITUATIONAL GENERALITY" OF THE WEBER LAW FOR LENGTH DISCRIMINATION

However, a more positive light is thrown by our data upon another classic of experimental psychology, the Weber law. When applied to the type of approach set forth in the present paper, the Weber law would lead us to expect that errors of judgment should on the average be the same for large and for small sizes, under the presupposition that the same logarithmic way of representation of errors is chosen which is used throughout this paper. In that case, numerical values of errors would, when taken from a sufficiently large sample of objects estimated, be in proportion to the size of the object judged which is what, in essence, is called for by the Weber law.

In a first type of approach to this problem, the 93 situations were divided into two groups, one containing relatively large, the other relatively small objects. An effort was thereby made to equate the two groups for distance in a manner analogous to that shown in, and discussed in connection with, the middle pair of rows in Table 2, the difference being that the two groups compared are here equated for D instead of for B. The purpose of this stipulation was to ex-

clude the size-constancy aspect of the problem altogether. In this form the problem is approached in as good accord with the classical psychophysical tradition as is possible, i.e. with distance differences eliminated. There remains as a new feature only the sampling of objects and distances from natural situations which enables us to test the generality of the Weber law in terms of the conditions prevailing in everyday life.

In particular, the following procedure was adopted in segregating the two groups of extensions. Within each of the nine distance categories resulting from a subdivision of the D-scale in steps of .5 logarithmic units, as shown by the oblique lines in Figure 2, objects were divided according to their bodily size into two groups as nearly equal in number as possible. There was a further stipulation requesting that at the same time the total average of the distances of all the objects classified, within their distance categories, as "small", should be as nearly equal to that of the "large" objects as possible. To fulfill this second desideratum the two groups had to be made slightly unequal in number. There were 45 objects in the "small" as contrasted to 48 in the "large" group, due to the fact that in the next to the lowest distance category it was decided to have 15 "small" vs. 17 "large" objects so that the effect upon the D-averages of the one extremely large and distant object in our total distribution (see Figure 2) could be offset.

The results of this procedure are shown in Table 4. As can be seen from the third column, the logarithmic average distance is in fact very similar for the two groups. One of the consequences of this fact is that the distinction between B and P which is so important whenever questions of size constancy are involved need not be particularly kept in mind since whatever holds for B will under these circumstances hold approximately for the variable P as well. As is further shown in Table 4, the B-averages are at the same time more than sufficiently different for the two groups, though of course not quite as different as would be the case if the stipulation of equating the distance averages had not been made. In fact, the difference of almost 1.00 logarithmic unit existing between the logarithmic B-averages of the two groups indicates that our "large" objects are on the whole almost ten times as large as those in the corresponding group of "small" objects.

TABLE 4

Data pertinent to the confirmation of the Weber law for length discrimination

Object sizes	No. of objects	Ave. log B (mm)	Ave. log D (m)	Means of absolute errors $\lvert \log^b - \log B \rvert$	
				Subject Mean ± $\text{Sigma}_{\text{Mean}}$	Experimenter Mean ± $\text{Sigma}_{\text{Mean}}$
Small	45	1.87	.60	.118 ± .015	.081 ± .012
Large	48	2.84	.61	.117 ± .004	.075 ± .011

The remaining portions of Table 4 show averages of errors, computed logarithmically, and with the signs discarded, i.e. averages of $|\log b - \log B|$, for both subject and experimenter. The values computed for the "small" and the "large" groups are as nearly equal as could be expected. This holds for both subject and experimenter. The existing small differences are far from significant as can be seen from the attached measures of variability. It may thus be said that, as far as the specific manner in which the Weber law has been interpreted and applied here is concerned,

its "generality" seems to be confirmed in the most satisfactory way.

A second type of evaluation of our material pertinent to the Weber law may be briefly discussed in addition to the one already presented. Laying aside any regard for distance, and thus for projective size, objects have been classified into three categories according to their bodily size. The "small" group comprises the 34 objects smaller than 10 cm., the "medium" group the 34 objects between 10 cm. and 1 meter, and the "large" group, 25 objects larger than 1 meter. Average distances are of course quite different for the three groups (in fact, about 10 times as large for the "large" as for the "medium" group). In its general form this approach is analogous to that shown in the uppermost group of three rows in Table 2. In effect, it allows for all the natural concomitant variation of the distance with the size of those objects upon which our attention happens to become focussed. This approach thus does not concern the Weber law in its traditional sense, but rather a broadened conception of the Weber law resulting from its combination with the "law" of thing constancy.

For the "small" and "medium" groups of objects averages of logarithmic absolute errors were again found to be very similar, for both subject and experimenter. There was, however, some increase as we proceeded to the "large" group. (To save space, the data are not shown in detail.)

Whether or not the latter fact may be taken as an indication, however indirect, for the generality of what has been called the "breakdown of the Weber law at the extremes" shall not be further discussed here. May it suffice to say that a similar procedure to that just outlined for B has also been followed through for P and for D, dividing them in three categories regardless of the other two variables concerned. For distance, results were found to be very similar to those reported for B. "Small" distances (under 1 m.) and "medium" distances (from 1 to 3.16 m.) showed about the same average amount of (logarithmic, relative) errors, with means of .058 and .059, respectively, for the subject, and of .053 and .050, respectively, for the experimenter. In contrast to this, errors are significantly larger for distances greater than about 3 m., namely .144 for the subject and .094 for the experimenter.

Chapter V

Coefficients of Correlation of Distal and Proximal Size with Perceptual Estimates

We proceed now to a presentation of the correspondence between measured variables and perceptual estimates in terms of correlation. As contrasted with measures of error, such as the constant error, used in the preceding section to represent perceptual achievement, the correlation coefficient possesses the major disadvantage of being limited to the representation of the degree of preservation of order, when the manifold of measured sizes is compared with the manifold of estimated sizes. This limitation is in contrast with the full representation of numerical correspondence between the objective and subjective scales which is offered, for example, by the constancy ratio, or by the measures of error. Nevertheless, from a biological (functionalistic) point of view such preservation of order may in itself be of value to the organism and hence worthy of notice by psychology.

Figure 3 shows the results rearranged in such a way that the relationships between physical (geographical) data and the subject's estimates can be expressed by correlation coefficients. The physical variables appear along the abscissae. In the two left-hand figures these abscissae represent the logarithms of B, and in the two right-hand figures, the logarithms of P. (Distances are disregarded in both cases.) The subject's responses are represented along the vertical axes, whereby the two upper diagrams refer to estimates of bodily size, which thus have been named b, and the lower diagrams to those intending to get at projective size, which thus have been named p.

Highest correlations should be expected where corresponding, or "homonymous," geographic and response data are brought together, that is, in the upper left diagram combining B and b and the lower right quadrant combining P and p. The relationship is indeed closer for these two quadrants than for the remaining two "heteronymous" ones which refer to how good the subject was in estimating bodily size when she wanted to estimate projective size (comparison of B and p, lower left), and vice versa (comparison of P and b, upper right).

It is also obvious that within the two homonymous quadrants by far the better agreement, i.e. the closer adherence to the diagonal of the figure, is found in the upper left figure which combines B and b. This is just another expression of the goodness of perceptual size constancy, as contrasted with a comparative lack of perceptual focalization upon the proximal sensory stimulus, even when such an attainment of, or constant relationship to, the variable P is purposely sought (by shifting toward an analytic destruction of the natural, habitual attitude of perception which is directed toward bodily things) as is done in attitude p.

Numerically, the correlation between B and b, or the degree of perceptual size constancy is, for our subject, represented by a Pearson r, corrected for grouping, of $r_{Bb} = .99$[17] (Table 5, left part; the arrangement of the coefficients corresponds to the arrangement of the four

[17] More precisely, this coefficient is .969 uncorrected, and .988 corrected for grouping.

scatter diagrams in Figure 3.) Due to the enormous variability along both axes such a high correlation is quite compatible even with the occasional grave heteronymous quadrants. The latter two figures do not, however, mean very much, since, as was pointed out in connection with Figure 2, the two geo-

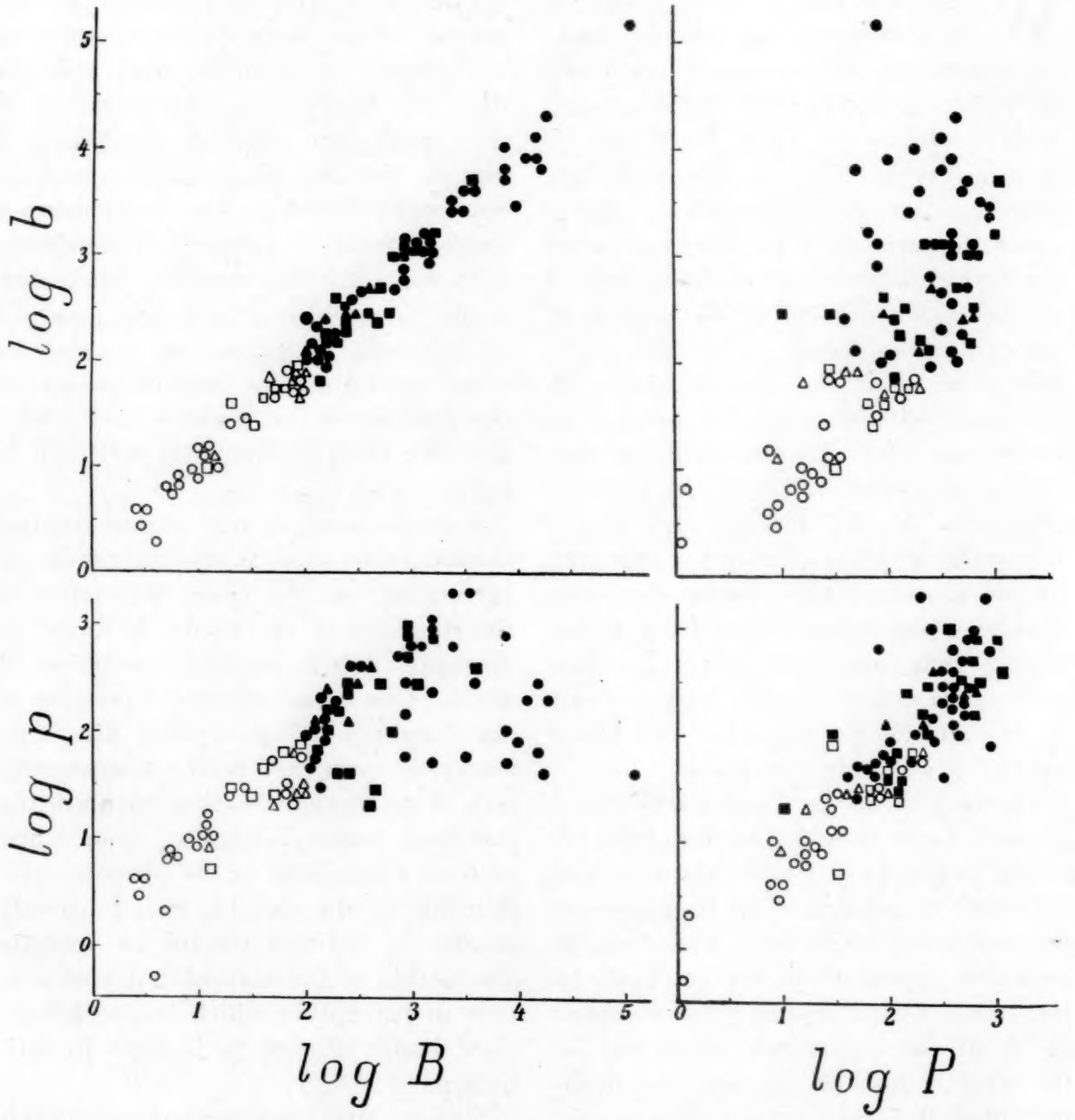

FIG. 3. Scatter diagrams for the correlation between geographic variables B and P, and estimates b and p as given by the subject. (As in Figure 2, solid symbols refer to objects greater than 10 cm, outline symbols to objects smaller than 10 cm.)

errors of judgment which we have noted above. For the remaining quadrants the correlations are still relatively high, namely $r_{Pp} = .85$ for the lower right, and $r_{Bp} = .72$ and $r_{Pb} = .73$ for the two graphic variables, B and P, are correlated almost as high (.70) as are these two pairs of heteronymous variables.

An elimination of this obscuring feature was attempted in the following

two ways: restriction to sizes above 10 cm., and the use of partial correlation.

The result of the former method can be intuited from Figure 3 directly by discarding the outline symbols and considering the solid ones only. As was reported above, for this sample of 59 objects the purely geographic, or ecological relation between B and P drops from .70 to .14 (cf. also Figure 2), and even more clearly: they are, in the same order as above, .97, .53, .00 and .05, with an ecological correlation between B and P of only .06. For this sample, r_{bp} (i.e. the correlation between the two main types of estimates) has also been computed and was found to be —.25, indicating the statistical independence of the two types of judgments.

The coefficients in the right part of

TABLE 5

Focussing of perception upon distal rather than upon proximal stimuli (size-constancy).
This is here illustrated by homonymous and heteronymous correlations of the geographic variables, bodily size and projective size (B and P), with uncritical perceptual estimates (b and p) given by the subject, based on the 93 frontal extensions, with r_{BP} left in (first part of table), as well as eliminated by partial correlation (second part) and by exclusion of small objects from the sample of extensions (third part).

	FOR THE 93 FRONTAL OBJECTS				FOR THE 59 FRONTAL OBJECTS LARGER THAN 10 CM.	
	(r_{BP} = .70 to be considered)		Net relationships after partialling out		(r_{BP} = .14 to be considered)	
			P	B		
r, corrected for grouping, between	B	P	B	P	B	P
b	**.99**	.73	**.98**	.40	**.95**	.21
p	.72	**.85**	.32	**.70**	.08	**.57**

thus the two variables may, as a first approximation, be treated as independently variable. The correlation then is still as high as .95, instead of the previous .99 (cf. Table 5, right part), for the upper left diagram in Figure 3. This again represents size constancy. But the correlation drops from .85 to .57 for the lower right quadrant (this quadrant represents perceptual attainment of relative retinal size when an effort is made to do so), and to a mere .08 and .21 for the remaining two heteronymous quadrants. The corresponding values for the 36 upright extensions out of the 59 extensions larger than 10 cm. (not shown in the Table) reveal the general trend Table 5 show, more clearly than those presented to the left, the paramount role of the perceptual constancy of object sizes. With a considerable drop in precision, projective or angular size, per se, is also attained perceptually to some extent, if the proper shift in attitude is taken; whereas heteronymous combinations show only a negligible amount of perceptual achievement.[18]

[18] This is in contrast to previous interpretations suggested by the present writer in consequence of the use of the constancy ratio as a measure of perceptual achievement. In that case the lack of perfect attainment of one of the two variables (or "poles of intention") in question appears automatically as an effect of the other, in a way which seems not quite justified in view of the present discussion.

In the middle part of Table 5, the net relationships are shown after partialling out P and B, respectively. The partial coefficients are in magnitude between the corresponding values to the left and to the right, and thus show a similar general pattern, confirming the conclusions drawn above.

In the previous publication (5) mentioned at the beginning of this article which also used the correlation coefficient as a means of expressing size constancy, an arbitrary selection of 15 cubes ranging from 5 to 7 cm. in size and placed at distances from 2 to 10 m. was used in a laboratory setup. The geographic relationship between B and P corresponded to a correlation r_{BP} of .10 and was thus similar to our .14 obtained here for sizes above 10 cm. The results calculated from averages of the estimates of eight observers, given in the natural b-attitude only, were in good agreement with those shown in the first line of the right part of our present Table 5, namely .97 instead of the present .95, and .26 instead of the present .21. The closeness of the numerical values should, however, be considered rather incidental, since the coefficients would no doubt have been quite different if other sizes or distances had been chosen for the experiment.

Correlation coefficients for both the uncritical perceptual attitudes and the betting attitudes have also been computed, for both subject and experimenter, using the 57 upright frontal extensions as a sample. Results summarized in terms of correlation coefficients are very similar for subject and experimenter though different errors were usually made in each single situation (see also Tables 1, 2 and 3). This is in line with the expectation, reasonably to be made on the basis of common observation, of the generality, from individual to individual, of the general scheme of perceptual focussing described above, though quantitatively the agreement may often be found to be less close. Results with the betting attitude show, in agreement with our previous findings (Table 1), on the whole a slight tendency toward improvement as far as the homonymous coefficients are concerned, and a corresponding slight lowering of the heteronymous coefficients. In particular, $r_{Bb} = .99$[19] and $r_{Bb'} = 1.00$ corrected for grouping and rounded, for both subject and experimenter. For the corresponding combinations of P with p coefficients are .87 and .90, for the subject and the experimenter, and with p′, .89 and .87, respectively. Thus the tendency toward an improvement with a shift toward the betting attitude is with respect to P true only for the subject. Heteronymous correlations are again close to the geographic or "ecological" correlation r_{BP} which for the 57 upright objects is equal to .75.

[19] More precisely, this value is .988 for the subject and .989 for the experimenter. For the subject, this coefficient has also been computed from the ungrouped logarithms of B and b. In good agreement with the upper figure, which is corrected for grouping, it was found to be slightly more than .99.

Chapter VI

Estimates of Distance and the Question of the Internal Consistency of the Perceptual System

The correspondence between the uncritical distance estimates d and measured or computed geographic distances D is represented, in terms of error, in the first row of Table 6, in a way analogous to Table 1 where the same was done for bodily size and projective size. Logarithmic constant errors with respect to distance compare favorably even with those with respect to bodily size, being about the amount of the latter for the subject and about half of this amount for the experimenter in his role as a control subject. This discrepancy, however, was not significant. The constant error itself is not significant for the experimenter, being not quite equal to its standard error. Absolute errors shown in Tables 6 and 1 are, however, sizeable and almost exactly the same for distance and for bodily size.[20]

Table 6

Comparisons between geographic and explicit as well as implicit behavioral distances, for the 93 frontal extensions.

	Deviations	Subject: Algebraic Means CE ±Sigma$_{CE}$	Subject: Absolute Means (Variability)	Experimenter: Algebraic Means CE ±Sigma$_{CE}$	Experimenter: Absolute Means (Variability)
Behavioral vs. geographic distances	log d − log D	−.030 ± .012	.114	+.009 ± .010	.077
	log d_{bp} − log D	+.153 ± .033	.278	+.155 ± .038	.319
Implicit behavioral vs. explicitly estimated behavioral distances	log d_b − log d	−.011 ± .017	.131	+.005 ± .016	.139
	log d_p − log d	+.201 ± .037	.328	+.141 ± .040	.329
	log d_{bp} − log d	+.178 ± .034	.298	+.149 ± .037	.309

By far the greatest single discrepancy between D and d for the subject holds in the case of a house of 14 meters height for which the geographic distance of 36 meters was estimated to be 12 meters, i.e. one third of its actual value. The maximum error of the experimenter is in logarithmic terms about the same, but in the opposite direction: a chimney of 42 cm. width at a distance of 39 meters was estimated to be at a distance more than three times as large, namely at 120 meters.

Correlations (again corrected for grouping) between D and d are likewise as high, if not higher, than those between B and b, namely .99 in the case of the subject and 1.00 (rounded) in the case of the experimenter, for the 57 upright frontal extensions. For comparison see the figures quoted at the end of Chapter V.

An interesting side issue is the question of the agreement between the actual distance estimate and the distance which appears to have been "registered" or "taken into consideration," in a functionalistic or organismic (not, or not necessarily, also in an introspective)

[20] Distances estimated at random as a pastime by an expedition of astronomers in the Pacific revealed a wide range of estimates in each situation, with their averages, however, being close to the true values (1, p. 128). This is in line with our findings on intra-individual dispersions of errors from situation to situation.

sense, when the size judgment was established on the basis of the mediating proximal stimulus pattern. In the field of Gestalt- (form-) constancy as well as of size constancy, in a sizeable proportion of instances (about twenty in one of the three studies quoted below) a relatively high degree of perceptual constancy has been found in spite of a complete negation, in an explicit perceptual sense, of the existing—and implicitly registered—difference in spatial orientation or distance, respectively, between standard and variable stimulus (18, p. 538 ff.; 30, p. 626 f.; 25, p. 458 ff.). This seemingly paradoxical result points toward a considerable amount of internal inconsistency within the perceptual system. Koffka (31, p. 229 f.) has questioned this result on account of the alleged scarcity of evidence and for reasons derived from his theories in a manner which seems, however, not quite convincing to the present writer.

The present study is not capable of furnishing, in itself, conclusive evidence on this point, primarily because the clearcut case of the non-recognition of a difference in distance is not given in our study since direct comparisons of situations have not been made by the subject. Indirectly, however, there is some evidence available.

The case can best be illustrated by referring to Figure 2. As far as the geographic data represented by the various types of symbols are concerned, there is strict consistency. Though three axes have been drawn, one for B, one for P, and one for D, each object is characterized by one point only, due to the univocal interdependence of the three variables as mathematical functions of one another in the physical universe.

No such internal consistency could, however, be found for the tips of the arrows connected with each of the large symbols. As will be recalled, the location of these arrowheads was determined by using the two subjective estimates, b and p, as coordinates. Each point so determined automatically refers to a certain distance when related to the third axis. This distance, "implicit" in the combination of judgments b and p, and thus to be labelled d_{bp}, does, however, only exceptionally coincide with the line, perpendicular to the D axis, which would represent the verbalized, "explicit" ("conscious") distance estimate, d, given by the subject in the given situation.

In other words, only exceptionally do we find that the distance which apparently has been underlying the act of judging an object to be so and so large and at the same time to produce a projective value of such and such magnitude, does correspond to the distance estimate as actually phrased by the subject. In most cases these two types of distance, d_{bp} and d, which are both organismic or "behavioral" distances—i.e., implicit or explicit responses to distance on the part of the perceptual system—, are nonetheless different.

In Figure 2, this could have been represented by adding a second arrow to the first, which would have to extend from the head of the arrow parallel to the D axis in one direction or the other until it reached the line representing the explicit distance judgment. Greater length of this arrow would represent a higher degree of internal inconsistency of perception.

An alternative way of representation would consist in constructing the two points corresponding to a combination of b and d, and p and d, in addition to the already existing point, b,p. The resulting triangle could also be used to represent perceptual inconsistency. In case of perfect internal consistency in judging the three variables the three points would coincide in one as does the combination of the three physical variables. Only in the case of internal consistency combined with external correctness of all the estimates, however, would this one point also coincide with the point representing the combination of geographic measurements.

The second row of Table 6 shows the average discrepancies between the type of implicit distance d_{bp} introduced above and geographic distance. Thereby, d_{bp} is defined as $\log b - \log p$ (which is equivalent to the logarithm of b/p). It is evident that this implicit type of constant error by far exceeds the constant error computed from explicit d. The difference is highly significant. Variability about the correct value has likewise increased.

This fact is interesting to note, but it does not yet refer to our problem proper, namely the discrepancy between implicit and explicit behavioral distance. A comparison of this type is made in the lower part of Table 6. Actually three kinds of implicit distance are used there and contrasted with explicit distance. The last of the three is d_{bp} as defined above; the first two are what might be called fractionated implicit distances; d_b is defined as $\log b - \log P$, or, in other words, the distance which appears to have been taken into consideration, in a functionalistic sense, in establishing the judgment on bodily size, the other constituent of which is the relative size of the physical retinal stimulus; and d_p is defined as $\log B - \log p$, or in other words, as the distance which appears to have been taken into consideration, in a functionalistic sense, in establishing the judgments on projective size in an attempt to get away from the habitual perceptual attitude to implicitly construct bodily size from relative retinal size in conjunction with peripheral cues for distance. (Thus d_p actually relates to the undoing of a step which in itself presupposes some kind of reference to distance of the general kind represented by d_b.)

As can be seen from Table 6, the distance estimates implicit in the judgment b, namely d_b, do not differ very much from explicitly estimated distance. There is however a considerable discrepancy when d_p is compared with d. Obviously, thus, quite different behavioral distances must have been eliminated in the natural concentration of the subject on b, in establishing p, than those which are explicit in d. The last row in Table 6, referring to implicit distance d_{bp} combined from the judgments b and p, shows a picture quite similar to that obtained for d_p. In this row, the answer is given to the question put forward above as to the average length of the additional arrows which could be introduced in Figure 2. Since large discrepancies occur in all three of those instances in which p appears in the subscript, and in those instances only, it may well be said that the chief contributor to the internal inconsistency of distal perception must be sought in the inability of the perceptual system to discard the established distance cues, rather than in an inability to use them in a fairly consistent manner.

In comparing the second and fifth rows of Table 6 it appears that compound implicit distance, d_{bp}, shows about as much average deviation (algebraic as well as absolute) from geographic D as it does from explicitly estimated d. Both discrepancies are multiples of the one found in the first row between explicit and geographic distance. There is thus a considerable amount of external discordance with the corresponding physical variable along with the internal inconsistency with other data within the perceptual system.

In further illustration of the inconsistency of distance perception, reference may now be made briefly to the greatest single discrepancies between implicit and explicit distance. We may begin with the case which shows the least amount of deviation, namely the comparison between d_b and d. For the subject, the absolute maximum of the discrepancies is represented by a difference of +.47 of the logarithmic scale, or about as much as the distance between two of the oblique lines extending from the upper right to the lower left of Figure 2. It is the case, mentioned previously in Chapter IV, of the height of a column of 10.5 meters at a geographic distance of 11 meters which according to the resulting projective size, 955 mm., and the bodily size erroneously assigned to it by the subject, of 2.9 meters, should have been seen at a distance of $d_b = 3.03$ m. whereas explicitly estimated distance d happened to be much more nearly correct, namely 9 m. For the experimenter, the maximum discrepancy is even more drastic, namely +.94 logarithmic units, corresponding to not much less than the full length of a diagonal of one of the cells, or two distance-class-intervals, in Figure 2.

Discrepancies between implicit distances in which p appears as a subscript and ex-

plicit distance are correspondingly larger; they run up to -1.16 for the subject, in the same situation as above; the distance of the column to be derived from its actual size, 10.5 m., and the estimate of its projective size, 8 cm. (instead of the correct value of 95.5 cm.) would have had to be $d_p = 131$ m. instead of the explicitly estimated 9 m. (The implicit distance to be derived for this situation by combining the two estimates, $b = 2.9$ m. and $p = .08$ m., is $d_{bp} = 36$ m.) For the experimenter, the absolute maximum of a discrepancy between d_p and d is represented by the value $+1.24$.

Though, in an indirect way, the internal inconsistency of the perceptual system seems on the whole to be corroborated by our results, a few qualifying remarks should, however, be appended. To be sure, data on self consistency (reliability) of explicit as well as implicit functional distances would be needed in addition to our data in order to make the proof complete. Such data could be obtained, for example, by letting the subject repeat distance judgments for the same series of situations at another time. This has not however been done in this study. The good agreement between d and D shown in the first row of Table 6 might be taken as a hint that reliabilities would probably be good. Furthermore, one would have to consider the fact that a certain time interval and a number of shifts in attitude were interposed between the judgments b and p on the one hand, and d, on the other, which certainly did not make for greater consistency.

All evidence for internal inconsistency of the perceptual system is in support of what may be called the "autonomy" of the perceptual system as contrasted to the more explicitly rationalized approaches to reality such as measurement and computation which bear the marks of logical consistency. In the hierarchy of mental functions, perception appears to be among the more "primitive"; internal contradiction being one of the main defining characteristics of such primitiveness (4).

Chapter VII

Application of the Constancy Ratio to our Material

The constancy ratio referred to in the introduction may be adapted to our material primarily in two ways. Since the constancy formula is based on a direct "behavioral" (subjective) equality of two objects at different distances (in the typical case of a "Standard" and a "Variable") some adjustments will have to be made to the formula for both ways in which we may apply it. To simplify the discussion, estimates of the type b (naive realistic perception) will be considered only, though all considerations would apply *mutatis mutandis* equally well to judgments of the type p or to the two kinds of betting attitudes.

(1) The first and simpler method will deal with single estimates b and arbitrarily assume that they have been made with reference to an imaginary series of objects at a fixed distance, say, for the sake of simplicity, at one meter, as in the case of the p-judgments.

Taking the isolated square symbol in the lower middle portion of Figure 2, representing the width of a chimney, as an example, it may then be said that its true bodily size B of 420 mm. has been estimated to be like that of an object of b = 300 mm. (as indicated by the arrowhead) at our fictitious reference distance of one meter, whereby the physical size of its projection upon a frontal plane at the same distance, P, was computed to be 10.8 mm. The constancy ratio[21] is then

$$c = \frac{\log b - \log P}{\log B - \log P} = \frac{\log 300 - \log 10.8}{\log 420 - \log 10.8} = \frac{2.477 - 1.033}{2.623 - 1.033} = .91,$$

indicating the underestimation of this relatively distant object (the geographic distance is 39 m.) in terms of approximation to the constancy ratio of 1.00 which would indicate perfect perceptual achievement in this respect.

Constancy ratios could in this way be computed for each of our 93 situations. Other arbitrary reference distances could be chosen instead of 1 m., in which case the P-values would have to be multiplied by the new reference distance. In order to keep constancy ratios comparable with one another, the same reference distance would, however, have to be used throughout.

"Over-constancy" (i.e. values of the constancy ratio greater than 1) will result whenever objects further away than the reference distance are overestimated or objects closer than the reference distances are underestimated in size. It is apparent that there would be a considerable number of such cases whatever the arbitrary reference distance might be. The choice of the reference distance would, however, unduly affect the way in which results would be represented, for each particular object, in terms of the constancy ratio.

A further inadequacy lies in the fact that for objects at distances close to the reference distance the constancy ratios would be disproportionately sensitive to errors of estimation due to the fact that P in these cases would be nearly equal to B.

(2) In view of these shortcomings a procedure seems to be more adequate which would consider two objects at a time and thus do away with the necessity of assuming an imaginary Variable at an arbitrary reference distance. One may look for objects at different distances which have been estimated to be of the same size and compare their B's and P's. The only assumption to be made is that the objects would also have been estimated as equal with regard to b had the two situations been viewed in close succession instead of having been judged at widely different times in terms of a common abstract scale.

The procedure to be followed would consist in selecting pairs of situations for which the arrowheads lie on the same vertical and

[21] The symbols used in this study are different from those of previous publications (3, 5, 46), but are readily translatable into those of the previous studies.

which thus are equal-appearing with respect to bodily size. Either one of the two objects may then be treated as the Standard or the Variable without effect upon the result provided that the logarithmic form of the constancy ratio is chosen (cf. 4, p. 67 f.), the geographic distance of the Variable to be used as reference distance for the projective values. Let whichever of the two objects is treated as the Standard be characterized by B, P, D, and the Variable by B′, P′, D′. Since, by hypothesis, the Standard looks, with respect to bodily size, like the Variable B′, B′ takes the role of b in the constancy ratio as given above. The value of B in the formula remains unchanged, but for P the projective value relative to the distance of the Variable, that is PD′, must be substituted for P. Thus

$$c = \frac{\log B' - \log PD'}{\log B - \log PD'}$$

which may be further transformed, by substitution of B′/P′ for D′, into

$$c = \frac{\log P' - \log P}{\log P' - \log P + \log B - \log B'}$$

This ratio will be 1 whenever there is no objective discrepancy between the bodily sizes B and B′ which, by hypothesis, have been judged as equal.

For our previous example as the Standard, a reference case would be given by the triangular symbol in the middle of Figure 2 with a short arrow pointing upward in such a way that its head is on the same vertical line as the head of the arrow of the Standard. For this extension, the size of a bag, B′ is 260 mm. and P′ is 92.8 mm. According to the above formula, c is found to be .82 for this particular combination of objects.

A case of over-constancy is given when, instead of the triangle, the square symbol closest to the Standard and with its arrowhead again along the same vertical as that of the Standard is used as the Variable. This is due to the fact that the new Variable, being at a closer distance than the Standard, is nevertheless underestimated to a larger degree than the standard. For this Variable, the length of a street sign, B′ is 700 mm. and P′ is 31.3 mm., resulting in a c of 1.9. The unusually high overconstancy value of the ratio is in part due to the relatively small difference in distance between the two objects which makes for exaggerated sensitivity of the constancy ratio as has already been pointed out above.

In a genuine sense, this technique applies only to combinations of objects with equal b estimates. Further assumptions would make it possible to include pairs with unequal b as well. The subject's total performance in size constancy could then be represented by, say, the mean and the sigma of the constancy ratios for all possible combinations of the 93 situations. Quite aside from the laboriousness of such a procedure, the reader will have noted the reasons for which the correlation coefficients and even the constant error seem to be preferable for many purposes as means of representing the total achievement in a sampling study such as the present one.

Chapter VIII

Discussion of Results: "Statistics" versus "Experiment" in Stimulus-Response Analysis

As will be recalled from Chapter I, the present study combines the use of two basic features of the practice of investigation that has developed especially with the growth of the biological and social sciences and has become known under the term "statistical". The first is the correlation coefficient as a measure of perceptual size constancy introduced in a previous publication (5). The second is new with this study. It is an attempt to secure a representative sample of task situations from which the paired values of the stimulus- and response-variables to be correlated with one another could be drawn. The present study thus can be used for a juxtaposition of the traditional experimental "style" or pattern of investigation and a relatively new approach to stimulus-response problems which is more in keeping with the spirit of statistics in all of its ramifications and implicit connotations. Given the choice of any single criterion to distinguish "statistics" from "experiment", the present writer would vouch for the second of the above mentioned features, "representativeness", as contrasted with the "systematic" character of the experimental approach.

To be sure, there are elements of the statistical pattern in nearly every actually performed psychological experiment. These elements involve, however, usually only one of the two groups of components determining the response studied, namely, the factors in the responding organism expressed in terms of inter- and intra-individual differences. In contrast to this, the present study endeavors to extend these same statistical principles to the other group of independent variables, namely the realm of those stimuli which are to be studied —in the further course of the investigation—as possible factors in the causal ancestry of the responses in question.

It is to be noted that correlating stimuli with responses in a representative population of situations is a departure, from the customary procedure of correlating tests in a population of individuals, which is of a different, more radical kind than the "inverted" correlational technique (Stephenson, 41). In this latter technique there is a mere exchange of the role of individuals and tests by correlating persons on a sample of tests instead of tests in a sample of persons.

(A) Representativeness vs. Systematic Design of Variables, Variation, Covariation

The idea of representative sampling, when transferred from the study of individual differences to the study of the responses of an organism to its environment may be applied, firstly, to the choice of the variables to be studied for their ability to elicit specific responses in the organism, secondly, to the manner of variation (range and distribution within this range) of these variables, especially of those to be classified as "independent", and thirdly, to the manner in which such variables are allowed to covary (to vary concomitantly) with other variables in the field.

In the traditional experimental approach all three of these aspects of research procedure are handled arbitrarily,

and mostly in a "systematic" fashion. Variables are often taken from the inventory of dimensions established in physics which does not consider typical organism-environment problems. The distribution of values usually follows an arbitrary range often dictated by the convenience of the experimenter, and within this range is mostly of a rectangular type with, say, an equal number of presentations of stimuli for each of a number of evenly spaced intervals.

Covariation with other variables is eliminated as much as possible. Probably the most characteristic policy of the classical experimental systematic approach is the "rule of one variable" (46), or what Lewin calls the technique of the "pure case" (32, p. 25). In its simplest form it takes its start from the ideal of eliminating covariation from the environmental variables by keeping all conditions constant (or at least under control) except for one independent variable, and to study concomitant variation in the dependent variable.

It has often been overlooked that in thus artificially untying the natural relationships between the so-called independent variable and many other variables in the field, this independent variable is artificially made to covary in strict unison with some of the remaining variables. The independent variable has thus not really been isolated. On the contrary, it becomes confounded with these remaining variables in an inseparable cluster.

An example is the classical psychophysical approach to length discrimination as represented, e.g., by the Galton bar experiment. The two halves of the bar to be compared are at the same distance. The fact that distance is kept constant leads, however, to a perfect tie of distal and proximal size (B and P in our study). Whenever the two bodily lengths are objectively equal they are at the same time projected in equal length upon the retina. A judgment of equality given in this situation yields no objective criterion by which it could be decided which one of the two variables—if any—is the crucial stimulus upon which the response is focussed, ideally or at least approximately. At best there may be an introspective criterion—such as Brentano's awareness of intentional reference to the object—but this cannot be unconditionally trusted in any analysis of perceptual achievement (see 4, 25). Neither do the major results of classical psychophysical studies, threshold values, give any answer to such questions of selective focussing or stabilization of stimulus-response relationships. Results of such studies thus possess extremely limited generalizability.

As is pointed out by the present writer elsewhere (7, p. 265, and also in a paper now being prepared) the "experimental" and the "nomothetic", i.e. law-finding, policy are inseparably tied to one another and to the "molecular" or "microscopic", low-level-of-complexity type of approach (see also 35, 38). The "laws" uncovered by pure case experiments are in a sense not the most general, but, on the contrary, the most specific type of result to be found in the sciences. (This holds to a considerable extent even if an effort is made to combine such laws with one, another or in a multiple-variable design considering "interaction" within certain limits.) Concentration of scientific effort upon the search for absolute laws thus represents one of the fallacies in the ideology of the exact sciences, at least as far as their more "molar" (43) purposes are concerned. To a good measure, this is due to the unrecognized ties between variables, tacitly slipping in with the experimental technique.

In experiments on perceptual size

constancy, distance and thus projective size, are made somewhat independent of bodily size. They are therefore experiments of a "crucial" kind, setting up one variable against another instead of throwing them together in one cluster. Yet, since in an experiment all variations are systematic, there is a definite set or matrix of combinations of the various values of the variables leading to what might be termed "artificially interlocked" covariation. Examples for this are not only experimental studies of the more traditional type, such as that of Holaday (25), but also the author's previous correlational study (5). The latter is an experimental-statistical hybrid, but still fundamentally on the experimental side, if representativeness is taken as the major criterion. So also are most other multidimensional and correlational approaches including the multiple-variable design of experiments using the analysis of variance technique (20, 16, 17). It must be remembered that this latter quasi-statistical technique imposes restrictions upon the range—and thus upon the freedom and representativeness—of variation and upon covariation which are definitely on the rigid, systematic side, such as the necessity to pair each value of each factor or dimension with each value of every other variable under consideration.

One of the best goals for which orthodox experiments can be, and have been, properly used is the ascertainment of such minimum, or all-or-none, facts as the presence, at least under some conditions, and thus the possibility, of a certain mechanism. One such mechanism is the elimination of a variation of distance from the perception of object size in perceptual size constancy. Generally we find in this category the question of the contributingness, or else the non-contributingness, of a certain factor to an explicit response. Questions of degree of compromise and relative weight, of competing influences, of proper balance or unbalance of contrast and assimilation in compensatory mechanisms, which become so important in perceptual research, however, seem especially unsuited for the experimental approach at least if the molar aspects of adjustment to the actual environment rather than the more academic questions of mediational technicalities are in the foreground of interest. Stated in this form they represent more the ecological, or the historic-geographic, high-level-of-complexity, than the systematic type of question in the sense of Lewin (32, 33) which makes it understandable why they can be answered satisfactorily only statistically and not experimentally.

In line with statistical, and in contrast to systematic, experimental procedure, in the present study interference with the independent stimulus conditions has been cut to a minimum. Not more than the first of the above aspects, the bare choice of the variables—as distinguished from the manner of their variation and covariation—has been planned in advance and brought under active control. That is, the size of the bodily objects, B, their distance from the subject, D, and the angular size under which they project upon the retina, P, have been made to play, alternatively and in combination, the role of independent variables, whereas their variability and covariability was random and merely under passive, observational control by what hardly was an "experimenter".

The choice of these variables, though technically arbitrary, seems nevertheless justifiable from the standpoint of representative-

ness by the fact that they are generally recognized as highly important for the orientation of any higher organism in the world in which he lives.

Our concentration upon these variables is not only reflected but in a sense almost constituted by the fact that the experimenter was asked to measure them rather than others, such as, e.g., the color of the objects, the pattern of their surroundings, the distance cues available in each situation, etc. The latter variables are left to vary freely within wide limits of "normalcy" relative to the world we live in. Except for such rather casual "class control" their specific values remain unknown, though potentially knowable and utilizable, throughout our investigation (see Section D of this chapter).

Like the independent variables, the dependent variables b, b′, p, p′, d, were also selected by an advance decision. An attempt was made to have the subject (and the experimenter in his role as a control subject, preceding his topographical survey of the objective stimulus values in each situation chosen by the subject) supply them by taking the respective attitudes. As well as seemed possible, it was undertaken to show through an objective analysis of the results that the responses of the type b, p, and d, were of a genuinely perceptual rather than of a rational kind (see Chapter IV B).

In spite of this technical arbitrariness in selecting the dependent variables, it may again be argued that they are fairly representative of perceptual activities of human beings. There can be no doubt that this is true for the attitude toward bodily size and distance which are among the most relevant features of manipulation and locomotion. For projective size there is at least the practical situation of perspectively correct drawing or painting. Furthermore, taking this attitude is the most urgent concession that can be made to the traditional mediational type of research which is so much interested in questions such as to how well we are capable of responding, explicitly, to stimulus features at the "skin" if we do our best to concentrate on these sensory, proximal aspects of the situation ("constancy hypothesis", see Chapter IV A and Koffka, 31).

The fact that the response variables do not vary, or covary, in any ideally "systematic" way, but are characterized by smoothly rounded distributions and non-perfect correlations with one another and with the independent variables is a trivial one. In fact, this is true for both statistics and experiment. In the former technique both independent and dependent variables do vary and covary representatively, whereas in an experiment the independent variables—or at least the environmental variables among them—are made to vary systematically. But there always is representative variation and covariation with the independent variables on the part of the dependent variables, limited, of course, in the case of an experiment, by the specificities introduced through the artificial character of the variations and covariations in the field of the independent variables. Especially the results of a psychological experiment thus introduce an element of the statistical approach—reflecting the representatively varying and covarying personality variables referred to above—into the experimental procedure.

(B) ECOLOGICAL ANALYSIS: DISTAL OBJECTS VS. MEDIATING PROXIMAL PROJECTIONS

The second aspect of the independent variables, B, D, P, namely their manner of variation, is left to the spontaneity of the subject and hence can be considered symptomatic of the environment as re-

sponded to by the subject rather than of the environment as dictated by an autocratic experimenter. The unsystematic, more or less normal distribution curves characterizing ranges of variation and frequencies for the three variables, as shown in Fig. 1 (Chapter III), are indeed part of the result of our investigation rather than of any advance design as would be the case in any orthodox experimental study.

The same policy of non-interference has been followed as far as the relationships of these variables among one another and with the remaining variables in the field are concerned. Thus, not only the manner of variation of B, D, and P, but also their covariation, is part of the result of our study rather than of a preconceived plan.

Representative covariation of a number of independent stimulus variables as introduced in the present study into the investigation of the perception of size shows neither perfect untying (correlations of zero)—and a corresponding perfect tying (perfect correlations)—of the various pairings of the geographic variables B, D, and P, as would be the case in classical psychophysics (see Section A). Nor does it lead to interlocked systematic combination, as would be the case in laboratory experiments on the constancies, but rather to the unsystematic, casual covariation as shown by the symbols in Fig. 2 (Chapter III). Their distribution closely resembles those found in typical individual differences scattergrams. The "ecological" correlation coefficient between bodily sizes, B, and their retinal projections, P, is .70 for the entire sample of 93 frontal extensions.

This correlation shrinks, however, to .14 when extensions smaller than 10 cm. (constituting the chief domain of near vision) are left out. Here we have another of those cases cherished by philosophers of statistics in which there is practically complete "statistical" independence in spite of the presence of an unquestionable causal relationship—in any sense in which this term has ever been accepted—between B as cause and P as effect in each of the individual historic-geographic situations. This causal relationship is further underscored by the equation $P = B/D$, expressing strict functional (mathematical) interdependence of the three variables which exists whenever these variables are conceived in an idealized geometric scheme based upon the laws of physical optics. The statistical independence of B and P, which is of course quite compatible with their causal relatedness, is of great help when it comes to the analysis of perceptual achievement and of the focalization of the responses (Chapter V).

Another means of elimination of the ecological correlation of .70 between B and P in the treatment of the results has been partial correlation. Used judiciously, this technique may become an equivalent of the experimental policy of holding conditions constant in the study of stimulus-response relationships as it has always been, of practical necessity, in the study of individual differences. In fact, it may even be regarded as an improvement upon the experimental technique insofar as the attempted isolation of variables is not real but exists only within the abstractions of computation. In experiments of the classical psychophysical type in which the attempt at an isolation—futile as it may be—actively interferes with conditions by artificially rendering correlations to be either zero or perfect, there is no way of satisfac-

torily isolating B and P by means of the correlation technique, or by any other means, for that matter.

As discussed in Chapter III, the perfect mathematical interrelation existing within the three-fold group of B, P, and D, is borne out by partial correlations of either 1.00 or —1.00. Such a perfect covariation, at least in abstraction, is a feature quite unheard of in the field of organismic variables studied in terms of individual differences. But it would be quite common in an ecological analysis of the type of variables with which the physicist is primarily concerned.

It is evident that in size constancy research both systematic and representative covariation of stimulus variables remain possible, depending upon the outlook and aims of the investigator. There are, however, types of research for which it would be very difficult to use systematic covariation. Probably the most striking example is social perception, such as the intuitive estimation of leadership or intelligence of human beings from their physical appearance, or from photographs. Since in this case not only the reacting subjects but also the stimulus-objects are persons, individual differences and stimulus-response psychology are here found in curious intersection. Such "neighboring" variables as the patterns surrounding physical objects estimated for their size, or the shape and color of these objects, as well as "mediating" variables such as their retinal projections can be handled or kept constant in a fairly authoritarian way by any experimenter. But it seems nearly impossible to secure a group of social perceptual objects of varying intelligence yet, say, constant (or else ideally covariant) leadership qualities (a neighboring variable), or of constant (or else ideally covariant) height, length of nose, color of skin, or any other characteristic of the external physique which may participate in the mediation of the inner personality to the observer. Thus research in social perception (such as, e.g., 14) could not even attempt to "isolate" its crucial stimulus variables however fallacious such an isolation may be in the last analysis. Workers in the field of social perception were from the beginning forced to use stimulus material imbued with natural variation and covariation just as were the early students of heredity who established the correlation technique. The same type of natural variation and covariation is deliberately sought for in this study for a type of material that has thus far always been approached in a systematic fashion.

It should be made clear, however, that the present writer advocates the use of representative stimulus samples and relationships not only where this becomes inevitable, or as a playful demonstration, but rather as a matter of positive scientific principle. We are today witnessing a convergence of the traditional academic and the applied and social branches of psychology, and thus of experiment and statistics. This is a step on the way to greater methodological unity within a more perfectly integrated science of psychology. It may, then, be well to point towards such recent topics of research as social perception which categorically call for a full-blown statistical pattern with all of its explicit or implicit ingredients complete.

(c) ANALYSIS OF PERCEPTUAL ACHIEVEMENT (FOCUSSING OF RESPONSES)

Perceptual achievement is here defined as the relationship, established by the organism, between a natural class of responses and a class of stimuli, or, in short, as representative stimulus-response covariation.[22] With the independent and dependent variables chosen as they were, the major alternative is between the distal stimulus variable, bodily size, B, and its major mediating proximal stimulus variable, projective

[22] The correctness (or incorrectness, say, illusory or hallucinatory character) of a single response does not in itself constitute proof of an "achievement" in perception as defined here (or of its absence), just as a single coincidence, say, of high intelligence with high forehead, would not be accepted as proof of an existing correlation.

size, P, as the focus of perceptual organization.

Both the analysis of errors and of variability (Chapter IV) and the analysis in terms of correlation coefficients (Chapter V) clearly point toward a preponderance of B-reference over P-reference of perceptual responses, with a compromise tendency between the two references. In terms of correlation coefficients, undisturbed perceptual size constancy (i.e., size constancy in the natural, naïve realistic attitude, b) is in the high nineties, even if the ecological covariability of .70 between B and P is eliminated, either by the exclusion of small objects from the total sample of 93 frontal extensions, or by partial correlation (.95 and .98, respectively: see Table 5 and Figure 3). The high coefficients in spite of the presence of occasional large errors of judgment are due in part to the unusual variability of B extending over a range of 5 powers of 10, the largest object being about 100,000 times the size of the smallest (see Figures 1 and 2). The mediating variable under investigation, projective size, is attained to a much lesser extent (.57 and .70, respectively).

These results are nothing but a confirmation of a long emphasized tenet, that of the "approximate size constancy of phenomenal things" (angenäherte Grössenkonstanz der Sehdinge) emphasized since the days of Helmholtz and Hering and approached experimentally by a series of investigators, most recently by Holaday (25, see also 2). The generality of such matters as the degree of approximation to an ideal constancy, or of the compromise principle, with the normal life conditions of a civilized human being as the "reference class" (population of situations), could, however, not have been ascertained by casual observation or in any laboratory experiment but only by the securing of a representative sample of the reference class as was attempted in the present study.

It is an encouraging sign for the apparently not too unrepresentative choice of laboratory situations in at least some of the traditional experiments on size constancy that the general trend and proportion of results is quite similar to those of the present study. In this sense, the major results of our study may seem commonplace. A checkup of this kind is, however, a methodological requirement whenever the soundness, in a representative sense, of the premises of an experimental design is to be put to test.

On the basis of the results of Beryl and of Holaday on size constancy (after recomputation on a logarithmic basis) and of Mohrmann (36) on loudness constancy when the distance of a sound source is varied, the present writer (4, p. 70) concluded that logarithmic constancy ratios in problems involving changes of distance, and conducted under conditions only moderately curtailed with respect to the intuitive surveyability of the spatial arrangement, tends to be in the .90-ies for the natural attitude (directed towards bodily size, or intensity of sound at the source, respectively) and somewhere in the broader range around the middle of the constancy scale for a reduction attitude (directed towards projective size, or intensity of sound at the ear, respectively; see 4, p. 53). It is of course not possible to compare the numerical values of constancy ratios directly with our error scores, their variabilities, or with correlation coefficients. But the greater closeness of b to B than of p to P, as well as the compromise character of both b and p between the

poles B and P is nevertheless evident.

Furthermore, there is excellent agreement, with the numerical values directly comparable, between the present study and the previous correlational study of the present writer (5), even though the latter was still conducted under arbitrary laboratory conditions (see Chapter V).

Thus it may be concluded that distal rather than proximal focussing upon magnitude existed in our subject.

To be sure, the inter-individual rather than the situational generality of this result has not been scrutinized in our study, but its assumption seems highly reasonable because of the representativeness of our subject, the very close correspondence between her results and those of the experimenter in his role as a control subject, and because of the general agreement, within rather broad limits of variability, to be sure, of the results of a variety of subjects in the experimental studies on size constancy such as those just mentioned.

The close numerical correspondence of the results of the two subjects is shown in Chapters IV and V in a variety of ways. The only major difference lies in the fact that the subject tends generally to underestimate sizes whereas the experimenter as a control subject tends to slight overestimation. This difference refers, however, to a rather absolute aspect of constant error which has little to do with the perceptual constancies.

An important part of our results has, to be sure, not been checked by any control subject. It is the automatic selection, on the part of the subject, of the stimuli to be responded to, for which an ecological analysis has been made in Chapter III. With respect to this selection, the experimenter functioned in his major role as objective surveyor of the situations involved. At the moment at which the subject was stopped to start a new series of estimates, the experimenter did not know at which objects the subject was looking so that the experimenter may be assumed not to have interfered with the selection of the objects.

To the present writer the fact of distal rather than proximal focussing of responses seems of great general importance in psychology. It is by virtue of the relatively stable physical properties of solid objects as well as of their approximately stable representation in the perceptual response system of the organism that this organism becomes oriented in an organized, fairly predictable "world". Classical psychophysics is incapable of furnishing information about the degree to which such mastery has been attained. For, whereas a high threshold for length may lead to an increase of errors by a few per cent of a standard, this same standard would be over- or under-estimated a hundred- or thousand-fold if there were no constancy mechanism to stabilize our relationship to the object world. In this sense the classical policy is indeed penny-wise, pound-foolish.

In line with the importance, to the organism, of a stabilized object reference in perception, traces of this mechanism appear already in babies (8, 15) and high constancies are found in higher animals (31, 46). Piaget, in some of his more recent publications, has increasingly emphasized the importance of "conservation", i.e., the perceptual or conceptual discovery of more and more constancies in the environment—of such variables as number, volume, physical energy, etc., which tend to persist under a variety of changes in other aspects of the situation —as one of the fundamental principles in the development of the child. And in a similar vein, though with important material differences, Claude Bernard and Cannon (13, see also 21) have pointed out how another stabilization

mechanism, "homeostasis"—establishing a constancy of the "internal" environment, e.g., of blood temperature—makes us free to live in a widely expanded world.

There is an intrinsic limitation to the degree of perfection of such mechanisms, however. No external constancies can ever become fool-proof. This is due to the probability character, i.e., the intrinsically non-perfect validity, in a statistical sense, of all the cues and means utilized in approaching the world of objects in perception and in action (see 7, 44). Representative stimulus-response covariation, i.e., the relations between the organism and the more remote distal environment, have of necessity to remain probability functions of greater or lesser approximation to ideal perfection. This is quite clearly borne out by our results. In this sense, the present study is nothing but an elaboration on William James' (29) statement that "perception is of definite and probable things".

Emphasis upon stabilization mechanisms such as the perceptual constancies seems part of a general "functionalistic" program in psychology, as foreshadowed by James and adopted by American Functionalism, though not actually carried out at that time on an adequate level of complexity that would include the aspect of stabilization. The general outlook of functionalism stems from Darwin and his emphasis upon practical adjustment to the environment in a struggle for existence. Thus, as has recently also been emphasized by Boring (2, especially Chapters 7 and 8), the study of perceptual constancies is part of a truly biological approach although it is, per se, quite detached from physiology.

In Chapter IV C, the compromise tendency between distal and proximal focussing has been pointed out by means of an analysis of the changing direction of the arrows indicating errors of judgment in Figure 2 as we pass from one part of the diagram to another. To further illustrate this point, it would have been possible to compute "heteronymous" error scores to be defined as log b — log P, and log p — log B, respectively (in contrast to the "homonymous" ones presented in Table 1, log b — log B, and log p — log P, respectively), but it was considered sufficient to present the analysis in Table 2 instead. The scattergrams and tables in Chapter V illustrate the compromise principle in terms of correlation rather than of error scores.

The question of the perceptual compromise between object size and retinal size has actually been the starting point of the present investigation. When in seminar discussions it was questioned whether there actually is such a compromise tendency or whether, if all estimates of size of objects at various distances were taken together, there might not be the same tendency for over-and under-estimation in nearby as in far away objects (in which case constancy ratios would average 1.00 rather than, say, .95, if all situations were considered), the present writer found that he had no answer. To be sure, it had been emphasized since Hering that the "interpretation in depth of the retinal image is not perfect and stops halfway between the flat retinal image and the bodily reality", and ever since experimental results have pointed in the same direction. But it was clear that no experiment but only a representative statistical survey of the type undertaken in the present study could really settle possible doubts and objections.

In order to understand better the nature of the compromise tendency between bodily size and visual angle one may point to the ecological correlations between projective size, and bodily size as well as especially distance (see Chapter III). We may limit our consideration to sizes larger than 10 cm, thus excluding most of our material involving near

vision for which standard distance cues are plentiful and for which relationships of a character opposite to those which hold for the larger sizes and distances seem to hold. When we do so, the correlation between P and D is $-.34$. In this sense, projective size possesses objective validity—of a rather low and barely significant degree, at least—with respect to the distance of the objects that were under observation. Projective size thus has to be considered as one of the members of the "cue family hierarchy" of distance criteria, although certainly as one of the less distinguished in this family of, say fifteen or so members. Since we have reason to assume that each of these members carries a certain weight in the automatic evaluation of distance on the part of the perceptual system of the organism—modest as the power of a single cue of low validity may be in a given situation—, a large retinal image then will contribute to the impression of small distance and thus of a relatively large bodily size. This is exactly what is indicated by the compromise principle which thus can be reduced to the mechanism of interaction and vicarious functioning of distance cues, at least as far as the distance ranges not too close to the observer are concerned. (As a short cut in this argument one may point to the corresponding direct correlation between P and B of .14 or of .70 for the total sample.)

The possibility of an artificial, experimental establishment of new cues for distance, and for illumination in color constancy experiments, has been demonstrated or discussed by Holaday (25) and Fieandt (19). Considering the apparently very unstable character of these cues, and the rapidity with which they are extinguished, it seems reasonable to assume that new cues, highly valid as they may be within the limits of an experimental series, have similar reaction potentials as have cues of low validity but of longer standing (high statistical reliability).

The generality of the fact that the analytic attitude improves the relationship with projective size is most clearly confirmed in Table 5, showing the correlation coefficients between stimulus variables and response variables.

In contrast to the confirmations of previous assertions listed, the following claim of perceptual constancy experiments has however not, or at least not consistently, been verified in the present study. The present writer, interpreting results of Holaday and others, concluded that a shift from purely perceptual to corresponding betting attitudes would approximately cut errors with respect to both the distal and the proximal stimulus variable in half (4, p. 99f.). The present study has, however, shown a consistent improvement only for bodily size, whereas there was a deterioration for projective size in the majority of the pertinent comparisons made (see Chapters IV and V).

The situational generality of claims of previous perception experiments in fields other than the constancies have likewise been partly confirmed, partly not supported in an analysis of our material. There was a confirmation of the Weber law when freely interpreted by applying it to errors in natural situations which are far above threshold in terms of the standards of classical psychophysics (Chapter IV E).

No support, and even a slight counterindication below the level of significance, was given to the vertical illusion (Chapter IV D)[23]. This fact does not

[23] The material for an analysis of the Weber Law is implicit in the data necessary for the analysis of the constancies. Orientation in space

strike the present writer as a surprise. There was not much exact research on the vertical illusion in the history of psychology, and the easygoingness with which this alleged phenomenon is illustrated in the literature sometimes borders on the shocking. For example, in Luckiesh' well-known book on visual illusions, published in 1922 (34), the only figures illustrating this illusion are a vertical which halves a horizontal to which it is perpendicular, and the familiar drawing of a silk hat. In both cases there are abundant sources of illusion outside of verticality vs. horizontality, such as the number of parts into which a figural unit is subdivided, proportion factors introduced by the presence of rectangular areas, curvature, cues for three-dimensionality, and the like. Even such more respectable examples as the square that looks too high when presented upright can hardly be taken for granted as a representative case.

In fact, in a study like the present which endeavors to be representative and as close to life as an academic problem could ever hope to come, one would not even want to deal with verticality as an isolated feature, not to speak of verticality when tied to other factors in a non-representative fashion. The present results rather refer to verticality as found in natural ecological association with other stimulus factors whatever these factors or the strengths of their correlation with verticality happen to be. (This does, of course, not exclude that there may be no such ecological associations.) In this sense, and in this sense only, do we question the vertical illusion.

is, however, one of the side-aspects of the situations involved. The experimenter had been asked to register it, in first approximation, along with the data essential for the analysis of the constancies, since horizontal vs. vertical orientation was considered a good example for possible "neighboring contributors" (see Section D of this chapter) in the estimation of size.

There are numerous other instances in experimental psychology in which non-representative experiments have been overgeneralized even to the extent of being made anchors of an entire theoretical outlook or school point of view. An outstanding example is the wellknown Gottschaldt experiment, discussed and illustrated in most text books (e.g., 31, 46), which has been undertaken with the idea in mind to test the influence of past experience upon the organization of perception. The largely negative outcome of the Gottschaldt experiment can, however, in the opinion of the present writer, not be used as evidence of any generality against the experience hypothesis and in favor of a more genuinely Gestalt hypothesis of perception, since it uses geometric line patterns quite unrepresentative of the majority of stimulus configurations encountered by perceiving organisms. Rorschach ink blots, to quote just one outstanding example, are certainly more representative, though somewhat out of line in another direction, and they certainly unearth a host of empirically meaningful tendencies and assimilations to familiar objects in the subjects which respond to them.

It is not always easy to achieve representativeness, and some of the attempts to do so may be imbued with fallacies of their own. An example from the field of social perception close at hand to the present writer's work is the following. In collaboration with Reiter, the present writer (10) attempted to investigate a group of factors influencing the physiognomic qualities of human faces, using schematized faces in which height of forehead, distance between the eyes, height of the nose, and position of the mouth were varied systematically in an interlocked multiple-variable combine. In an attempt to check upon these results, Samuels (39) succeeded, obviously not without difficulties, in selecting from college yearbooks, so that the age and sex of the individuals, as well as the pose and size of the photographs, were uniform, "human faces which matched the . . . drawings very closely in all the controlled variables". As can be easily seen

from an inspection of Figure 2 in the article by Samuels, there remain quite a number of uncontrolled variables such as hair, ears, shape of the mouth, circumference of the face, etc. This in itself would of course not be a disadvantage if numerous representatives for each combination of traits could have been found. Since Samuels had only one representative for each combination, chance no doubt acted in the direction of emphasizing incidentals. The decrease in the degree of confirmation of Brunswik and Reiter's results when Samuels shifted from a plain repetition of these experiments (88% confirmation) to the photographs (63% confirmation) can thus not be construed as an argument against their generality.

As was pointed out by the present writer in a previous article (7), it is one of the curiosities of psychological methodology that the sampling problem of individuals has been so crudely neglected for a long time whenever individuals played the unusual role of stimuli rather than the traditional one of reacting organisms, as is true in the judging of intelligence or personality from photographs or first appearances. It is one of the purposes of the present study to help remove double standards of this sort.

Some findings of the present writer on the dependence of apparent intelligence upon height and breadth of schematized human figures were confirmed by Wallace (45) on what might be considered a satisfactorily representative basis, by using a magnification, reduction and distortion technique on photographs of actual persons which circumvents some of Samuels' pitfalls.

It seems generally possible, and practically often very desirable, to include certain elements of the experimental pattern of research into representative studies of stimulus-response relationships in order to get rid of disturbances introduced by some variables which the experimenter has reason to regard as insignificant or which he may on other grounds wish to exclude from the scope of the examination. Such selective exclusion is exemplified in the perception psychology of size by Holaday's (25) fractionated elimination, one by one, of distance cues under maintenance of the remainder of those naturally available. This policy is, however, to be sharply distinguished from the more atomistic and thus more harmful policy of the nineteenth century type of experimentation which preferred to have just one factor, such as, say, binocular disparity, present at a time, under the exclusion of all the others.

(D) POSSIBILITY OF AN ANALYSIS OF MEDIATING CUES AND OF CONTRIBUTINGNESS

It is in keeping with the fundamentally practical outlook of Functionalism that wide-spanning stimulus-response relationships, such as those between physical or social objects and responses should be approached under comparative neglect of the variables which causally mediate this relationship. In this sense our study, when stripped to a minimum, would above all include measurements of bodily size, and may omit measurement of distance and objective ascertainment of projective size.

Such a procedure would be analogous to those numerous studies in social perception in which personality traits, such as intelligence, were to be guessed from photographs whereby only the tested IQ-s and the estimates of intelligence on the part of the reacting subjects were specifically known, whereas the geometic features of the face and body as represented on the photographs were not considered in the evaluation nor even measured, but only kept within rather wide limits of normalcy ("class control" rather than "specific control"). Attainment or nonattainment of the one independent variable in question can then be expressed, say, by correlation coefficients (see Woodworth, 46, p. 251).[24]

[24] The fact that results of such studies, at least in the case of the judging of permanent personality

In this sense, consideration of projective size in our study is a concession to the traditional molecular approach, undertaken primarily to refute the "constancy hypothesis" inherent in traditional Structuralism. More positively, it represents an attempt to demonstrate methodologically the present-day convergence of the traditional academic interests concentrating chiefly upon the "how" problems of mediational "explanation", with the applied line of development concentrating on the "what" of practical adjustment of a wide-spanning, molar kind. The result is a type of study in three "layers": distal focus, mediating proximal stimulus, final response.

The best parallel in the field of social perception seems to be the study by Cleeton and Knight (14) in which measures of face and body build (bodily distal variables of the first order which here play the role of the relatively proximal mediating layer) were related to both the objective personality (distal layer of the second order) establishing the ecological correlations of "expression", and to the intuitive perceptual estimates of personality (final response), establishing the "impression" values of the cues mediating social perception. The over-all correlation between objective personality and estimates, representing "social perceptual achievement", is the one feature which this study has in common with the one-independent-variable approaches to social perception just referred to.

It goes without saying that mediation problems are by no means exhausted by the consideration of just one mediating variable, P, important as this variable may seem in the business of conveying the distal variable to the organism. As has been pointed out above, the correlation between B and P is none too good, certainly not as good as that between B and b which is mediated by P. In other words, the mediating variable P is unstable within the framework of the over-all relationship Bb which is relatively stable. Such an effect is possible only if the variability of P is compensated for by other mediating variables. These are, in our case, the cue family hierarchy of distance criteria.

In short, mediation of distal variables to the organism's response system is not only "variable", it also is "multiple". The entire mechanism is comparable, in a figurative sense, to light rays passing in a divergent bundle from one focus through a collecting lens and eventually converging in another focus (4, p. 96f.; 7, p. 258). The establishment of the constancies is thus "difficult" in an objective, functional sense referring to the complexity of its engineering, although it seems the easiest, most natural thing to the introspecting subject. To the latter mediating details have a way to "submerge", i.e., to remain implicit, in their mediating role. The necessity for a "duplicity"—encompassing direct projection and the cues indicating situational "circumstances"—in the mediation of the perceptual constancies was first clearly expressed by Bühler (12, see also 9). As a more general principle, the importance of "stimulus patterning" in connection with the idea of a "calculus of adaptive probability" was recently emphasized by Hull (28, p. 374ff.).

A complete understanding of mediation would require measurement of distance cues along with direct retinal projections of objects, thus increasing

features such as, especially, intelligence, are very discouraging must seem rather incidental. It can probably be explained by pointing to the absence of sufficiently valid cues. The constancies of such external properties of physical objects as size are very successfully established by the perceiving organism, obviously because of the larger number of relatively valid distance cues.

the number of independent variables considerably. The fact of distal focussing in perception implies that certain combinations of projective values and values of distance cues—the latter further complicated by "vicarious functioning" of the members of this cue family hierarchy—would show relationships with the distal stimulus B as well as with the final response b which would be at least as good as the over-all perceptual correlation linking B and b. Thus distal focussing is far from being magic; it is just a somewhat more complex causal relationship between B as a probable part cause and b as a probable part effect (see 7).

In the present study, the absence of even a passive, merely registering control of distance cues is matched by the freedom given to the subject to use those cues in a natural way to their best advantage.

The only restriction imposed upon another aspect of mediation—the somatic, physiological mechanisms involved—was not to move away from the point of observation as long as the estimates had not been concluded, and to keep the objects, if not fixated, in the focus of attention, otherwise reacting normally.

Appreciable interference with organismic variables was limited to the more ultimate aspect of mediation which emerges with the establishment of some of the dependent variables. This is the taking of attitudes toward perceptual reorganization, as well as exclusion or inclusion of the rational superstructure which is normally superimposed upon perception whenever it comes to decisions of a "betting" type in the practical life of normal human adults.

Naturally, all the neglected aspects could have been included had we been interested in a more thorough mediational analysis. Correlation coefficients would then have expressed perceptual achievement under elimination of, say, the distance cues present in binocular vision, or under conditions of dark adaptation, the influence of alcohol, etc.

In Chapter VI, an angle of mediation somewhat different from those just mentioned was demonstrated, namely that of the internal inconsistency of the perceptual system which is part of its relative autonomy of functioning when compared with the intellectual approach to reality. This was done by comparing the explicitly judged distances d with the distance-responses implicit in judgments of bodily size and of projective size. It was concluded that the chief contributor to the internal inconsistency of distal perception must be sought in the inability of the perceptual system to discard the established distance cues, rather than in an ability to use them in a fairly consistent manner.

An aspect somewhat related to problems of mediation proper is that of the influence upon the response, or the "contributingness", of such "neighboring" variables as the pattern of surrounding objects, the color of the object, etc. The term "neighboring" may be used for these variables to characterize the fact that they are not direct links in the causal chains mediating the focal variable, magnitude, to the organism, as are retinal projection or distance cues.

By measurements taken of neighboring variables, a large number of traditional problems of experimental psychology, e.g., the Müller-Lyer illusion, the influence of color upon apparent magnitude, etc., could be dealt with on an equal footing with some of the other

side issues approached in the present study, such as the vertical illusion. It is one of the advantages of a sampling study of stimulus-response relationships that the original material contains a large amount of implicit information and practically inexhaustible possibilities for the analysis of mediation and of the contributingness of neighboring variables if only the proper measurements be taken. In fact, it seems that nearly all problems of this type in perception could be approached by using the same sample of situations, measured and evaluated in their response-eliciting capacity in a variety of ways.

In the end, a factor analysis, not of personality variables, but rather of the stimulus variables determining a system of responses, could be undertaken. Such a factor analysis of the focal and contributing dimensions in the environment would establish a description of the reacting organism in terms of the stability of its rapport with the various stimulus variables, distal or otherwise, in short, "in terms of objects" (4, 7).

In the field of social perception, which has served as an example to illustrate many of our points of discussion, such phenomena as the "halo effect" would correspond to what we have called contributingness.

On the other hand, a study like the present one has the disadvantage of considerable clumsiness when compared with some of the simple laboratory tests or experiments. The present writer feels, however, that the advantages gained by at least a shortcut form of approach of the present type—perhaps one not even involving the computation of correlation coefficients—has its definite advantages over the use of standard experiments for purposes of testing. For example, the two-rod type of experiment in the form widely used in the testing of depth perception is certainly not representative of depth discrimination under conditions in which the monocular natural cues are not being cut out as much as they usually are in this test. As was shown by Holaday (25), binocular cues will add little to the efficiency of depth perception under such circumstances. Nor is the two-rod test representative of discrimination at greater distances. Generally, the scope and selection of tasks to constitute a representative test battery in the study of individual differences in abilities, hitherto largely left to common sense speculation, will have to be further scrutinized, at least to match the scrutiny which has become routine in the selection of the individuals to which the tests are given. Furthermore, whenever clinical statements concerning "loss of category" (Goldstein, 22), "social blindness" (Ch. Bühler, 11), and the like—referring to problems of focussing on certain more or less "abstract" environmental variables, and generally to selective alertness in the evaluation of stimulus patterns—are made, the only proper checkup seems to be in terms of a representative investigation. Such an investigation may be conducted on a larger or on a smaller scale, but it would basically have to follow the principle of natural sampling of task-situations, and it would most probably surpass in number and variety of observations the often quite casual material brought forward in support of the original claims.

Chapter IX

Summary and Conclusions

A "natural" sample of frontal "extensions" of various sizes and at various distances was secured by inducing, at random intervals, a student of psychology to designate whatever objects (extensions) she happened to be looking at at the moment.

The 93 extensions thus obtained from one subject were found to be normally distributed when the logarithms of their measured bodily sizes were plotted. Further, the "ecological" correlation between two of the "geographic" stimulus-variables characterizing each of the 93 situations, namely the bodily sizes of these extensions and the sizes of their representations on the retina of the subject (i.e. visual angle or "projective" size), was found to be far from perfect though positive when all size ranges were included. A natural flexibility of "proximal" (retinal) mediation—which is a necessary condition in the definition of each "distal" stimulus variable such as bodily size—was thus assured. The remaining mediating circumstances—such as especially the presence or absence of the various "distance cues"—as well as the mechanisms used by the subject (with the exception of mental attitude) in each situation were not specifically ascertained or interfered with in each case although on principle the method employed in this study would permit of such an extension of mediational analysis.

One of the principal significances of the present study, as the writer sees it, is that a traditional laboratory problem has thus been approached after the fashion of a statistical survey rather than of an "experiment". Stimulus situations have not been selected arbitrarily and controlled rigidly, but rather much in the same "representative" way as individuals are selected from a "population" in a typical study of individual differences. Generality of a stimulus-response relationship from one sample of situations or conditions to another ("situational generality" of a result) thus takes the place of what may be called the populational generality of the finding of investigations in which the correlated variables are tests paired by being given to the same sample of individuals. On the other hand, this situational generality is, at least on principle, limited to—and characteristic of—the one subject or attitude for which the survey has been undertaken.

The responses consisted in numerical estimates of each of the extensions given by the subject in a series of five more or less natural attitudes. These responses were quantitatively compared with the geographic data. Traditional measures of error of judgment such as the constant error were used along with the favorite tool of the statistical survey, the correlation coefficient, to characterize the various possible types of stimulus-response connections. (A comparison has also been made between these methods and the "constancy ratio" previously used as the quantitative expression of the perfection of perceptual thing-constancy.)

The results demonstrate again what is known as "perceptual size-constancy", namely the natural focussing of the per-

ceptual system upon the distal stimulus variable "bodily size" and its comparative inability to respond to even such an outstanding mediating proximal stimulus-feature as the retinal proportions, even when an effort is made to do so. There was good agreement between the results obtained from the subject and those obtained from the experimenter who had served as a control subject prior to his making the necessary stimulus measurements in each of the 93 situations.

The situational generality of some of the more specific findings of previous laboratory research on the constancies, such as the comparative over-estimation of near objects (perceptual compromise between distal and proximal focussing), and the improvement of estimates after shifting from purely perceptual to critically controlled ("betting") attitudes was also demonstrated by our subject, the latter, however, only for estimates of bodily size.

Overestimation of the vertical as compared with horizontal extensions was not, however, found in our data. Another side-line from traditional experimental psychology was likewise followed up, namely, the Weber law in its application to length-discrimination. The situational generality of this psychological principle was well confirmed by our data.

A certain amount of internal inconsistency within the perceptual system was revealed by the fact that "explicitly judged" distances varied considerably from various types of "implicit behavioral" distances as computed by combining the estimates of bodily size and projective size, and the true geographic measures. This inconsistency supports the writer's previously suggested interpretation of perception as a primitive and relatively autonomous function within the total cognitive system of the human being.

In conclusion, the writer would like to point out that the network of abilities characteristic of a certain organism—of a given species, age, state of mind, temporary physiological condition, or in command of a particular set of mediational cues and sensory instruments—might thus eventually be mapped out in terms of the intimacy, or safeguardedness (situational generality), of the rapport set up by the organism with the various vitally relevant issues in the nearer or more remote, physical or social regions of the geographic or historic environment ("psychology in terms of objects"). In essence, this implies a "biological" (as contrasted to a merely "physiological") attitude or program of research as it is inherent in psychology since the establishment of American Functionalism. The variables involved are thereby properly isolated in spite of—or rather because of—the absence of artificial control over the remaining circumstances. The selective focussing of organismic activity, may it be overt behavioral or covert perceptual, can thus be properly represented. The recognition of these achievements of living beings as probability functions with an intrinsically limited degree of perfection (due to the ecological ambiguity of cues if not to more intrinsically organismic imperfections as well) implies the convergence of the experimental and the statistical techniques in approaching problems of the stimulus-response type.

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